

Effect of a 12-week Community Horticultural Therapy Program on Cognitive Function and Activities of Daily Living in Older Adults with Mild Cognitive Impairment: A Randomized Controlled Trial

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Abstract

To investigate the effect of a 12-week structured community horticultural therapy program on cognitive function and activities of daily living (ADL) in older adults with mild cognitive impairment (MCI), 126 community-dwelling older adults with MCI were recruited from Cuqiao Subdistrict, Wuhou District, Chengdu, China. Recruitment took place between March and September 2025, and participants were randomized at a 1:1 ratio into an intervention group (n=63) and a control group (n=63). The control group received routine community health education and recreational activities, while the intervention group additionally received a 12-week structured horticultural therapy program (90 min per session, twice weekly). The curriculum progressed through sensory awakening, planting, maintenance, and harvest-based creative workshops, with each participant caring for the same potted plant from sowing through to indigo leaf printing, herbal bead bracelet making, and pressed-flower framing. Outcomes were assessed at baseline and week 12 using the Montreal Cognitive Assessment, Beijing version (MoCA-BJ), Mini-Mental State Examination (MMSE), Barthel Index (BI), Lawton Instrumental ADL (IADL) scale, and the 15-item Geriatric Depression Scale (GDS-15). A total of 116 participants completed the study (intervention group n=59; control group n=57). In week 12, the intervention group showed significantly greater improvements than the control group in MoCA-BJ total score (21.4 ± 2.3 to 23.9 ± 2.4 vs. 21.6 ± 2.2 to 22.0 ± 2.3), MMSE (25.7 ± 1.5 to 26.9 ± 1.3 vs. 25.5 ± 1.6 to 25.8 ± 1.4), BI (92.4 ± 5.6 to 95.8 ± 4.3 vs. 92.8 ± 5.2 to 93.1 ± 5.0), IADL (5.8 ± 1.2 to 6.9 ± 1.0 vs. 5.7 ± 1.1 to 5.9 ± 1.2), and GDS-15 (7.2 ± 2.6 to 4.8 ± 2.2 vs. 7.1 ± 2.5 to 6.8 ± 2.4), all $p < 0.01$. Attention was the cognitive domain with the most robust improvement, with additional mild gains in delayed recall, orientation, visuospatial/executive function, language, and abstraction. The 12-week community horticultural therapy program produced multidimensional benefits for cognitive function, ADL, and depressive symptoms in community-dwelling older adults with MCI, and is suitable for implementation in urban community eldercare settings.

Keywords

Horticultural therapy, Mild cognitive impairment, Cognitive function, Activities of daily living, Randomized controlled trial

Introduction

China is undergoing rapid population aging. Adults aged 60 years and above numbered 264 million (18.70% of the total) in the seventh national population census, and this figure is projected to exceed 400 million by 2035. Among this population, MCI represents a transitional state between normal aging and dementia. The 2024 Chinese expert consensus on the diagnosis and treatment of Alzheimer's disease-related MCI was released by the Neurology Branch of the Chinese Medical Association.

According to this consensus, the prevalence of MCI in adults aged 60 and above is about 15.00%. For amnesic MCI, the annual conversion rate to Alzheimer's disease (AD) ranges from 10.00% to 15.00%. Its cumulative conversion rate exceeds 50.00% at 5-year follow-up [1]. Because individuals with MCI retain basic functional capacity, this stage is a critical window for intervention; progression to dementia carries profound caregiver and societal costs.

Currently, first-line pharmacotherapies for AD (cholinesterase inhibitors and memantine) are indicated primarily at the dementia stage, have limited efficacy in MCI, and carry peripheral adverse effects. Non-pharmacological interventions have therefore become a research priority.

Horticultural therapy uses plants and gardening as its therapeutic medium. It emerged in the United States in the 1970s and is widely adopted for dementia care in Japan, the United States and China's Taiwan region. Ng et al.'s Singapore RCT found an 8-week community horticultural intervention improved executive function and subjective well-being in Asian older adults [2]. Huang et al. reported in 2025 that horticultural therapy improved cognitive function, basic psychological need satisfaction, and quality of life among nursing-home residents with MCI [3].

A recent meta-analysis by Li et al. confirmed a moderate positive effect of horticultural therapy on cognitive function in dementia and MCI populations, with the most stable effect observed at a frequency of 2-3 sessions per week lasting 45-60 min [4].

Nevertheless, existing evidence has three limitations. First, most studies focus on nursing home residents, while community-dwelling older adults with MCI - the majority of MCI patients - are understudied in RCTs. Second, intervention protocols vary greatly. Structured long-duration (≥ 12 -week) curricula targeting specific cognitive domains are rare; many studies only vaguely state that horticultural activities were provided. Third, most outcomes are restricted to global cognitive scores, with limited data on domain-specific changes, so it is hard to determine which cognitive domains improve. This RCT thus evaluated a 12-week structured community horticultural therapy program. We measured global cognition, domain-specific cognition, ADL and depressive symptoms to provide empirical evidence for non-pharmacological community MCI interventions.

Methods

Study design

This was a single-center, parallel-group, randomized controlled trial conducted in Cuqiao Subdistrict, Wuhou District, Chengdu, China, following the Consolidated Standards of Reporting Trials (CONSORT) guideline. The study used an assess-intervene-reassess design. All participants were fully informed of the study purpose and procedures before enrollment.

Participants

Between March and September 2025, community-dwelling older adults were recruited from Cuqiao Subdistrict through the Cuqiao Community Health Service Center and its five neighborhood committees (Qili, Jincheng, Longjing, Xincheng, and Shuangfeng). Recruitment channels included poster displays, family physician referrals, and on-site promotion at community events. The subdistrict is a typical urban-renewal residential area serving approximately 100,000 residents, with a relatively high proportion of older adults aging in place. Inclusion criteria: (1) Age ≥ 60 years. (2) Meeting Petersen's criteria for MCI - subjective or objective cognitive decline, preserved basic ADL, and not meeting dementia criteria [5]. (3) MoCA-BJ < 26 and MMSE ≥ 24 . (4) ≥ 6 years of education, able to complete scales independently. (5) Able to regularly attend the community day-care center. (6) written informed consent. Exclusion criteria: (1) Established dementia, severe psychiatric illness, or other progressive neurological disease. (2) Severe cardiac, hepatic, or renal impairment precluding gardening activity. (3) Severe sensory impairment or aphasia. (4) Allergic to plants, soil, or common horticultural supplies. (5) Participating in another cognitive intervention trial within the prior 3 months.

Sample size

Sample size was estimated using MoCA-BJ as the primary outcome. Based on effect sizes reported in previous horticultural therapy studies, with $\alpha=0.05$ (two-sided), power=0.90, expected between-group difference $\delta=1.5$ points, and pooled standard deviation (SD) $\sigma=2.4$ points, the formula

$$n=2[(Z\alpha/2+Z\beta)\sigma/\delta]^2 \quad (1)$$

yielded a requirement of at least 54 participants per group. Anticipating a 15.00% attrition rate, 126 participants were recruited and allocated 1:1 (63 per group).

Randomization and blinding

A statistician independent of recruitment and assessment generated the random allocation sequence using the Statistical Product and Service Solutions (SPSS) 26.0 (IBM Corp., Armonk, New York, and the United States), with 1:1 allocation. Allocation was placed in sequentially numbered opaque sealed envelopes, opened in enrollment order. Because of the intervention nature, participants and therapists could not be blinded. Outcome assessors - two trained research staff

uninvolved in the intervention - were blinded to group assignment.

Intervention

Both groups received routine community elder health services: a monthly chronic-disease lecture, twice-weekly community calisthenics, and regular chess or card recreational activities. The intervention group additionally received a 12-week structured horticultural therapy program. It's delivered by a certified horticultural therapist in a dedicated horticultural activity room at the community day-care center, twice weekly (Tuesday and Friday mornings), 90 min per session. The

room was fitted with height-adjustable tables, anti-slip gardening tools, potted plants, craft supplies and natural light.

Each session included a 10-min warm-up and introduction, 60-min themed horticultural activity and 20-min review or sharing, with a therapist-to-participant ratio of 1:6. Participants tended the same potted plant from sowing through week 12. Weeks 1-9 focused on sensory awakening, planting and maintenance.

Weeks 10-12 used their plants for indigo leaf printing, herbal bead bracelets and pressed-flower frames, completing a seed-to-craft cycle (in Table 1).

Table 1. Twelve-week structured horticultural therapy curriculum.

Week	Phase	Theme	Key activities	Targeted cognitive domain
1	Sensory awakening	Orientation and seed selection	Smell and identify rosemary, mint, lemon balm; each participant selects own herb/vegetable/flower combination	Attention, olfactory memory, decision-making
2	Sensory awakening	Medicinal herbs identification	Observe goji berry, chrysanthemum, tangerine peel, monk fruit; learn meridian entry properties	Semantic memory, categorization
3	Preparation	Planting kit pickup	Receive pot, seeds, label, small tools; make a name tag; learn tool safety	Naming, writing, sequential execution
4	Planting	Sowing	Sow tomato, marigold, or mint seeds in trays; cover, firm, water	Fine motor, executive function
5	Planting	Transplanting	Move own seedlings into individual pots; practice supporting, filling, firming	Hand-eye coordination, sequential execution
6	Planting	Cutting propagation	Take mint cuttings from own plant; extra seedlings for family gifts	Motor planning, working memory
7	Maintenance	Watering and growth diary	Finger-test soil moisture; water plant; measure height and record leaf count	Judgment, sustained attention
8	Maintenance	Pruning	Pinch back kalanchoe, trim leggy growth; learn pruning shears	Fine motor, executive function
9	Maintenance	Weeding and soil loosening	Weed and loosen soil around own plant; observe pests; draw growth chart	Visual search, visual representation
10	Harvest and creation	Leaf printing	Pick own mint leaves and marigold foliage; hammer-print natural patterns on cotton-linen cloth	Visuospatial processing, tactile discrimination
11	Harvest and creation	Herbal bead bracelet	String dried mint and rosemary with agarwood beads, hawthorn pits, goji berries; learn calming herbal lore	Fine motor, naming, semantic memory
12	Harvest and creation	Pressed-flower framing and exhibition	Frame own marigold petals and dried kalanchoe flowers; hold a mini-exhibition for family	Verbal expression, episodic memory

Note: First-aid kits and anti-slip gloves were provided at every session; the therapist observed continuously. Exercise load was controlled at 9-11 on the Borg Rating of Perceived Exertion scale (very light to fairly light).

Measures

Trained assessors administered all measures at baseline and in week 12.

(1) General characteristics: age, sex, years of education, marital status, living arrangement, and number of chronic conditions.

(2) Primary outcome - global cognition: MoCA-BJ (seven cognitive domains: visuospatial or executive, naming, attention, language, abstraction, delayed recall, orientation; total 30 points) and MMSE (total 30 points).

(3) Secondary outcome - ADL: Barthel Index (BI; total 100 points, basic ADL) and Lawton IADL scale (8 items, total 8 points, instrumental ADL).

(4) Secondary outcome - depressive symptoms: 15-item Geriatric Depression Scale (GDS-15; total 15 points).

(5) Safety: adverse events including falls, skin allergy, and muscle strain were recorded.

Statistical analysis

Analyses were performed using SPSS 26.0. Normally distributed continuous data are presented as mean $\pm$ SD. Within-group pre-post comparisons used paired t tests. Between-group comparisons used independent-samples t

tests. Categorical data are presented as n (%) and analyzed with chi-square tests. A two-sided $p < 0.05$ was considered statistically significant.

Results

Participant flow

Of 126 randomized participants, 116 completed the study. In the intervention group, 4 participants were lost (1 moved away, 1 was hospitalized for fracture, 2 withdrew for poor adherence), leaving 59. In the control group, 6 participants were lost (2 had acute exacerbation of chronic disease, 3 withdrew for poor adherence, 1 was lost to follow-up), leaving 57.

The overall attrition rate was 7.94% (10 out of 126); between-group attrition did not differ significantly ($\chi^2 = 0.437$, $p = 0.509$). No serious adverse events (falls, allergy) occurred during the intervention.

Baseline characteristics

The two groups did not differ significantly in age, sex, education, marital status, living arrangement, number of chronic conditions, or baseline scale scores (all $p > 0.05$), and were well balanced (in Table 2).

Table 2. Baseline characteristics and scores of the two groups (mean $\pm$ SD).

Variable	Intervention (n=59)	Control (n=57)	t/ χ^2	p
Age (years old)	72.4 $\pm$ 5.6	71.9 $\pm$ 6.0	0.472	0.638
Sex (male/female)	23/36	25/32	0.312	0.576
Education (years)	8.6 $\pm$ 3.1	8.3 $\pm$ 3.4	0.503	0.616
Married (yes/no)	45/14	43/14	0.011	0.917
Living alone (yes/no)	18/41	17/40	0.011	0.917
Chronic conditions (n)	2.4 $\pm$ 1.1	2.3 $\pm$ 1.2	0.471	0.638
Baseline MoCA-BJ	21.4 $\pm$ 2.3	21.6 $\pm$ 2.2	-0.481	0.631
Baseline MMSE	25.7 $\pm$ 1.5	25.5 $\pm$ 1.6	0.696	0.488

MoCA-BJ domain scores

At baseline, no significant between-group differences were observed across all MoCA-BJ subdomains and the total MoCA-BJ score (all $p > 0.05$), confirming that the two groups were well balanced in cognitive status before the intervention commenced. At week 12 after the 12-week horticultural therapy program, the intervention group achieved a MoCA-BJ total score of 23.9 $\pm$ 2.4, whereas the control group reached 22.0 $\pm$ 2.3. The between-group difference in total score was 1.9 points, with a t-statistic of 4.352 and $p < 0.001$.

At the subdomain level, attention demonstrated the strongest and most statistically robust improvement between groups (5.4 $\pm$ 0.7 vs. 4.9 $\pm$ 0.8, $p < 0.001$). Several

other cognitive domains also exhibited mild yet statistically significant between-group differences, including delayed recall (3.4 $\pm$ 0.8 vs. 3.1 $\pm$ 0.9, $p = 0.037$), orientation (5.6 $\pm$ 0.6 vs. 5.3 $\pm$ 0.8, $p = 0.024$), visuospatial/executive function (3.6 $\pm$ 0.8 vs. 3.3 $\pm$ 0.9, $p = 0.013$), language (2.3 $\pm$ 0.5 vs. 2.1 $\pm$ 0.5, $p = 0.002$), and abstraction (1.3 $\pm$ 0.5 vs. 1.2 $\pm$ 0.4, $p = 0.017$). By contrast, the naming subdomain showed no statistically significant intergroup difference at week 12 ($p = 0.052$).

Within-group comparison showed that the intervention group improved by 2.5 $\pm$ 1.2 points on MoCA-BJ total from baseline, versus 0.4 $\pm$ 1.0 points in the control group between-group difference in change score, $t = 10.218$, $p < 0.001$ (in Table 3).

Table 3. MoCA-BJ domain scores before and after intervention (points, mean±SD).

Domain (max)	Time	Intervention (n=59)	Control (n=57)	t	p
Visuospatial/executive (5)	Pre	3.2±0.9	3.3±0.8	-0.621	0.536
	Post	3.6±0.8	3.3±0.9	2.514	0.013
Naming (3)	Pre	2.1±0.6	2.1±0.5	0.000	1.000
	Post	2.3±0.5	2.1±0.6	1.962	0.052
Attention (6)	Pre	4.6±0.9	4.7±0.8	-0.631	0.529
	Post	5.4±0.7	4.9±0.8	4.318	<0.001
Language (3)	Pre	2.1±0.5	2.1±0.5	0.000	1.000
	Post	2.3±0.5	2.1±0.5	3.241	0.002
Abstraction (2)	Pre	1.2±0.4	1.2±0.4	0.000	1.000
	Post	1.3±0.5	1.2±0.4	2.412	0.017
Delayed recall (5)	Pre	2.9±0.9	2.8±0.8	0.630	0.530
	Post	3.4±0.8	3.1±0.9	2.108	0.037
Orientation (6)	Pre	5.3±0.8	5.4±0.8	-0.693	0.490
	Post	5.6±0.6	5.3±0.8	2.294	0.024
Total (30)	Pre	21.4±2.3	21.6±2.2	-0.481	0.631
	Post	23.9±2.4	22.0±2.3	4.352	<0.001

MMSE, BI, IADL, and GDS-15

At week 12, the intervention group scored 26.9±1.3 on MMSE versus 25.8±1.4 in the control group. BI was 95.8±4.3 versus 93.1±5.0. IADL was 6.9±1.0 versus 5.9±1.2. GDS-15 was 4.8±2.2 versus 6.8±2.4. All four between-group differences were statistically significant

(in Table 4).

In the intervention group, MMSE improved by 1.2 points, BI improved by 3.4 points and IADL by 1.1 points; GDS-15 declined by 2.4 points. In the control group, MMSE improved by 0.3 points, BI improved by 0.3 points and IADL by 0.2 points; GDS-15 declined by only 0.3 points.

Table 4. MMSE, BI, IADL, and GDS-15 before and after intervention (mean±SD).

Measure	Time	Intervention (n=59)	Control (n=57)	t	p
MMSE (points)	Pre	25.7±1.5	25.5±1.6	0.696	0.488
	Post	26.9±1.3	25.8±1.4	4.376	<0.001
BI (points)	Pre	92.4±5.6	92.8±5.2	-0.401	0.689
	Post	95.8±4.3	93.1±5.0	3.128	0.002
IADL (points)	Pre	5.8±1.2	5.7±1.1	0.467	0.641
	Post	6.9±1.0	5.9±1.2	4.905	<0.001
GDS-15 (points)	Pre	7.2±2.6	7.1±2.5	0.212	0.832
	Post	4.8±2.2	6.8±2.4	-4.713	<0.001

Note: BI, Barthel Index (higher=better basic ADL); IADL, Lawton Instrumental ADL scale (higher=better instrumental ADL); GDS-15, 15-item Geriatric Depression Scale (higher=more severe depressive symptoms).

Discussion**Cognitive effects**

This RCT demonstrated that a 12-week structured horticultural therapy program produced significant improvements in both MoCA-BJ and MMSE total scores among community-dwelling older adults with MCI.

The effect size was broadly consistent with that reported

by Huang et al. in a nursing-home setting, and somewhat greater than the 8-week program reported by Ng et al, suggesting that extending intervention duration to 12 weeks may yield more stable cognitive benefits.

At the domain level, gains were concentrated in attention, with additional mild improvements in delayed recall, orientation, visuospatial or executive function, language,

and abstraction. This pattern aligns with the curriculum design. Activities including sowing, transplanting, pruning, and leaf printing demand sustained attention to individual plants and sequential multi-step operation. These tasks repeatedly train sustained attention, working memory, and executive control. Moreover, the fixed Tuesday and Friday schedule over the 12-week intervention strengthens time orientation and prospective memory through regular repetition. The week-12 sharing exhibition directly trains episodic memory and verbal expression.

From a neurobiological perspective, olfaction is the only sensory pathway that projects directly to the parahippocampal gyrus, entorhinal cortex, and amygdala without thalamic relay. The curriculum's deliberate use of aromatic plants (rosemary, mint, and lemon balm) in week 1 means that volatile odor molecules activate the limbic system via the olfactory bulb. The entorhinal-hippocampal circuit is precisely the earliest site of neurofibrillary tangle and A β deposition in AD. This direct anatomical link may underlie the observed improvement in delayed recall. In addition, green natural environments exert restorative attention effects that reduce top-down prefrontal control load, indirectly supporting orientation and attention networks.

ADL effects

Both BI and IADL improved significantly in the intervention group. BI reflects basic self-care (dressing, feeding, toileting, and transfers), while IADL captures more complex instrumental abilities (shopping, cooking, medication management, finances, and transportation) that are among the first domains impaired in MCI and predict future institutionalization. Gardening is essentially a type of task-oriented occupational therapy. Activities such as potting, cutting, and leaf printing demand bimanual coordination and hand-eye control. These actions train upper-limb fine motor skills and joint range of motion.

Moreover, the complete plant-growing cycle involves assessing soil moisture, determining watering volume, selecting suitable plants, and recording plant growth. This process directly simulates the problem-solving and executive functions required for instrumental activities of daily living (IADL). Horticultural therapy combined

with training improved both cognitive scores and ADL in older adults with post-stroke cognitive impairment, suggesting that this functional transfer effect generalizes across etiologies of cognitive impairment [6].

Depressive symptoms

GDS-15 fell by 2.4 points in the intervention group (from 7.2 to 4.8), consistent in direction with the Singapore-based RCT by Ng. Older adults with MCI frequently experience stigma and withdrawal related to fears of cognitive decline. Depression both results from cognitive decline and, via HPA-axis hyperactivity, exacerbates hippocampal atrophy, accelerating cognitive loss in a vicious cycle.

The observed emotional improvement may operate through three pathways. First, the visible growth of a plant from sowing to flowering provides a clear care-response feedback loop that rebuilds self-efficacy and perceived control. Second, the group format inherently creates peer social contact, alleviating isolation and loneliness among community-dwelling older adults. Third, natural environment exposure has restorative attention effects that lower sympathetic arousal, consistent with observation that brief gardening activity reduces systolic and diastolic blood pressure [7]. It is worth noting that emotional improvement may partially mediate cognitive gains: Reduced depressive symptoms may improve participants' cooperation and motivation during cognitive testing, which may secondarily inflate cognitive scores.

Strengths

Compared with previous studies, the present trial has three strengths. First, this study expands its research setting beyond nursing homes. It targets urban community-dwelling older adults living with MCI, who represent the largest subgroup of people with MCI. The intervention was conducted at a community day-care center. Participants didn't need hospital referrals, and improves the generalizability of the findings [8].

Second, the curriculum is anchored by each participant caring for the same plant from sowing through to creative work, integrating traditional planting and maintenance with culturally Chinese craft activities (leaf printing, herbal bead bracelets, pressed-flower framing) that train visuospatial processing, fine motor skills, naming, and semantic memory [9]. The protocol is readily replicable

and culturally resonant.

Third, we reported domain-specific MoCA-BJ changes across all seven cognitive domains, enabling more precise identification of which dimensions benefit and informing future protocol optimization (e.g., adding pruning activities for those with weak executive function, aromatic plant exposure and herbal identification for those with weak memory) [10].

Conclusion

This RCT shows that a 12-week structured community horticultural therapy program, delivered twice weekly for 90 minutes each session, yields meaningful multidimensional benefits for community-dwelling older adults with MCI. The MoCA-BJ score increased by 2.5 points, and the MMSE score rose by 1.2 points. Attention exhibited the most prominent improvement ($p < 0.001$), while five other cognitive domains showed modest gains. In the intervention group, MMSE improved by 1.2 points, BI improved by 3.4 points and IADL by 1.1 points; GDS-15 declined by 2.4 points. In the control group, MMSE improved by 0.3 points, BI improved by 0.3 points and IADL by 0.2 points; GDS-15 declined by only 0.3 points. Because the program requires no specialized equipment or professional medical staff, is low-cost and safe, it can be integrated into community health-service-center follow-up after MCI screening and incorporated into home-based eldercare service packages. Future studies should extend follow-up to assess the persistence of effects at 6 months and 1 year, and should perform subgroup analyses by baseline cognition, living arrangement, and chronic-condition burden to identify the participants most likely to benefit.

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Conflicts of Interest

The author declares no conflict of interest.

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