BMC Medicine

RESEARCH

Open Access

Effects of an integrated social-art intervention on cognitive and psychosocial outcomes among older adults with mild cognitive impairment in nursing homes: a mixed methods study

Chenshan Huang[1†], Yuanjiao Yan[1†], Wilson Wai San Tam[3], Wenqian Sun[1], Yu Ye[1], Nafang Wang[1], Yanhong Shi[1], Ziping Zhu[1], Danting Chen[1], Lin Chen[4], Junyu Zhao[1], Rong Lin[1*] and Hong Li[1,2*]

Abstract

Background The rising prevalence of mild cognitive impairment (MCI) among older adults in nursing homes necessitates effective interventions to slow the progression to dementia. Integrated social-art interventions have shown promise in enhancing cognitive function and reducing social isolation. This study aimed to evaluate the effects of such an intervention on cognitive and psychosocial outcomes in older adults with MCI.

Methods An explanatory sequential mixed-methods study was conducted, comprising a cluster randomized controlled trial (RCT) and a descriptive qualitative study. Four nursing homes in two districts of a city in southeastern China were randomly assigned (1:1) to either the intervention or the control group. The intervention group received a 14-week, 28-session integrated social-art program structured around theme-based group activities, while the control group received usual care, including assistance with daily living activities, basic medical care, recreational activities, and environmental cleaning. Quantitative outcomes were measured at baseline (T0), immediately post-intervention (T1), and at 24-week follow-up (T2), with global cognitive function as the primary outcome, and specific cognitive functions, psychosocial indicators, functional abilities, and quality of life as secondary outcomes. Qualitative interviews were conducted post-intervention to explore the reasons underlying the observed variations in efficacy.

Results Eighty older adults with MCI (median age 86.50 years) participated, with an average attendance rate of 86.25% in the intervention group. Intention-to-treat analyses revealed a significant improvement in global cognitive function at T1 in the intervention group compared to the control group ($\beta = 2.85$; 95%CI [1.27, 4.44], $P < 0.001$); however, this effect was not sustained at T2. No significant improvements were observed in psychosocial indicators, functional abilities, or quality of life ($P > 0.05$). Qualitative findings indicated that structured, sequential tasks

[†]Chenshan Huang and Yuanjiao Yan contributed equally to this work.

*Correspondence:
Rong Lin
linrong2015@126.com
Hong Li
leehong99@126.com
Full list of author information is available at the end of the article

and professional guidance contributed to short-term cognitive gains, whereas age-related health issues and limited ongoing engagement impeded the durability of these benefits.

Conclusions The 14-week integrated social-art intervention appears feasible and may promote short-term cognitive activation in institutionalized older adults with MCI, though its benefits were not sustained at follow-up. Future research should investigate strategies for maintaining cognitive improvements and explore modifications to enhance broader clinical outcomes in this vulnerable population.

Trial registration The trial was prospectively registered at the Chinese Clinical Trials Registry with the registration number ChiCTR2200061681 on 30 June 2022.

Keywords Aging, Cognition, Art, Social, Non-pharmacological intervention, Mild cognitive impairment, Mixed method

Background

The rising prevalence of dementia, particularly Alzheimer's disease (AD), poses significant challenges to older adults' health and quality of life while burdening families and society [1]. Given the irreversible nature of dementia and the limitations of current treatments, early interventions to slow the progression from mild cognitive impairment (MCI) to dementia have become a public health priority [2–4]. The 2020 Lancet Commission reported that addressing 12 modifiable risk factors could delay or prevent 40% of dementia cases, with social isolation being a key factor, accounting for 4% of preventable cases [5, 6]. The COVID-19 pandemic has further highlighted concerns about social isolation [7]. Older adults in nursing homes are particularly vulnerable due to limited mobility and reduced social interactions, underscoring the need for targeted interventions [8].

Social participation is increasingly recognized as a key factor influencing cognitive health and dementia risk, defined as "engagement in social leisure activities, maintaining social networks, and deriving satisfaction from these interactions" [9]. It may protect the brain by enhancing cognitive reserve, which enhances cognitive adaptability and resilience against neurodegenerative processes without corresponding declines in cognition and function [10]. Participating socially demands significant cognitive effort, drawing on various cognitive domains such as planning, memory, and language [9]. The social brain hypothesis suggests that complex social interactions drive cognitive development [11]. Therefore, active social participation may strengthen cognitive domains and lower the risk of cognitive decline later in life [12]. Research indicates that strong social connections influence cognitive aging by mitigating neuropathological effects and preserving brain function [6]. A study found that frequent social contact before death weakened the association between amyloid burden and cognitive decline [13]. Additionally, a 28-year follow-up cohort study demonstrated that late-life social contact protects against dementia, with more frequent interactions linked to higher cognitive reserve [14]. A systematic review confirmed the link between social relationships and cognitive health [15], while a randomized controlled trial found that a 3-month social intervention significantly improved cognitive function, with sustained benefits observed 12 months later [16]. Institutionalized older adults may particularly benefit from structured programs that enhance social support and interaction frequency, leading to better cognitive functioning [17]. A qualitative systematic review further highlighted the cognitive and psychosocial benefits of such interventions in nursing home residents [18]. However, despite promising findings, the effectiveness of social interventions specifically for older adults with MCI in nursing homes remains unclear, as most studies focus on community-based interventions.

Arts-based interventions, including visual arts, music, dance, and literature, are recognized for their cognitive and psychosocial benefits. These interventions may slow cognitive decline, alleviate behavioral symptoms, and enhance quality of life, though no consensus exists on the most effective approach [19]. A meta-analysis found that various arts interventions positively impact cognitive function, behavioral symptoms, and mood, suggesting that combining multiple art forms may provide synergistic benefits [19]. Additionally, research indicates that arts-based group activities facilitate social interactions, promoting emotional expression, communication, and collaboration, which in turn enhance social participation [20, 21]. Consistent with a prior systematic review [22], non-pharmacological interventions that integrate social participation strategies show more promising outcomes. Cavallo et al. found that shared social participation among individuals with similar interests fosters mutual support and reduces the challenges of engaging in novel activities [23]. Thus, integrating social and arts-based approaches may be particularly effective in improving cognitive outcomes in older adults with MCI, though further rigorous research is needed.

A major challenge in implementing non-pharmacological interventions for older adults with MCI is the prevalent apathy and depression, which may hinder engagement [24, 25]. Self-determination theory (SDT) provides a framework for sustaining motivation by addressing autonomy, relatedness, and competence [26]. SDT-based interventions have been effective in promoting long-term health behavior adherence [27, 28]. Additionally, behavior change techniques identified by Michie et al. offer standardized strategies for enhancing intervention implementation [29]. Therefore, we employed an explanatory sequential mixed-methods design to evaluate a social-art intervention based on SDT for older adults with MCI in nursing homes. A cluster RCT was conducted to assess cognitive and psychosocial outcomes, followed by qualitative interviews to elucidate the reasons underlying the observed variations in efficacy.

Methods

Study design

This study employed an explanatory sequential mixed methods design [30] to evaluate the effects of a 14-week social-art integrated intervention on cognitive and psychosocial outcomes among older adults with MCI in nursing homes. The quantitative phase utilized a cluster RCT design, with nursing homes as clusters to mitigate contamination risk, assigning participants to either the intervention group (social-art program) or control group (usual care). The subsequent qualitative phase involved purposively sampled intervention group participants in semi-structured interviews informed by naturalistic inquiry principles [31, 32], aiming to elucidate reasons underlying intervention outcomes [33]. All procedures adhered to the Declaration of Helsinki were approved by the Ethics Committee of Fujian Provincial Hospital (K2022-05–015), and written informed consent was obtained from all participants, who also received souvenirs and certificates as incentives. The trial was registered in the Chinese Clinical Trials Registry (ChiCTR2200061681).

Study setting and participants

The study employed multi-stage cluster random sampling across two administrative districts of a city in southeastern China. Twelve nursing homes were assessed for eligibility between July and August 2022. Inclusion criteria for nursing homes comprised: (i) official five-star registration per Chinese national standards [34]; (ii) availability of self-care facilities; (iii) capacity to provide logistical support; and (iv) non-participation in similar interventions.

Eligible participants met the following criteria: (i) aged 60 years or older; (ii) diagnosed with MCI according to the Petersen criteria [35], including self/informant-reported memory complaints, objective cognitive decline (Montreal Cognitive Assessment [MoCA] score thresholds: ≤ 13 [no education], ≤ 19 [1–6 years], ≤ 24 [$\geq$ 7 years] [36]), preserved daily functioning, and absence of dementia (Clinical Dementia Rating [CDR] ≤ 0.5 [37]). Exclusion criteria included physician-diagnosed dementia or mental illness and insufficient visual or auditory acuity for neuropsychological testing. Recruitment strategies included posters, flyers, health lectures, educational videos, art experience activities, and peer encouragement. Written informed consent was obtained from all participants prior to study enrolment.

Sample size determination

Sample size determination was based on prior effect sizes from creative expression therapy studies in MCI populations [38]. Assuming a mean MoCA score difference of 1.55 (intervention: 24.68 ± 1.84 vs. control: 23.13 ± 1.68), a two-sample means formula ($\alpha = 0.05$, power = 90%) indicated 25 participants per group. Accounting for cluster effects [39] (intraclass correlation = 0.01 [40]) and attrition (20%), the adjusted sample size required 15 participants per cluster (4 clusters), totalling 72; 80 participants were ultimately recruited. A purposive subsample of 40 intervention-group participants, stratified by age, gender, and education for diversity [41], underwent qualitative interviews until thematic saturation, at which point additional interviews only reiterated data already gathered [42].

Randomization and masking

Randomization occurred after consent, registration, and baseline assessments. To avoid contamination, entire nursing homes were randomized (1:1 ratio) using a lottery method conducted by independent staff. Outcome assessors and statisticians were blinded to group assignments, while intervention providers and participants were not, and nursing homes were instructed to maintain this blinding.

Study intervention

Intervention group

Forty older adults with MCI participated in a 14-week integrated social-art intervention developed by a multidisciplinary team (neurologists, clinical nurse specialists, art therapists, and social workers). The program was conducted in nursing home activity centers and facilitated by two experienced instructors trained in group dynamics and certified in specialized art methods. Nursing home personnel—two social workers and one medical caregiver—were selected in collaboration with management based on their experience with older adults

and commitment to the program. These staff members received 24 h of standardized training, including activity simulations, discussions on potential challenges, and resolution strategies.

This program consisted of 28 sessions, each lasting 60 min, and was structured into two sequential modules: an art experience module, which introduced various artistic materials and forms of expression, and an art creation module, designed based on SDT [26] and behavioral change techniques [29], progressing through relatedness, competence, and autonomy. Techniques used included social support strategies, a points-based incentive system, and options for free artistic expression within a themed context. Each session followed a consistent format—beginning with ice-breakers, followed by thematic introductions that incorporated historical events, current social contexts, traditional Chinese culture, and nostalgia; then engaging in art creation, group discussions, and evaluation feedback (Fig. 1). More details of the integrated social-art intervention program are provided in Additional file 1: Tables S1–S3.

The intervention program integrated social interaction and artistic activities to enhance cognitive and psychosocial health. It proceeded in stages (Fig. 1): an initial evaluation aligned the program with participants' expectations, followed by a welcoming ceremony that fostered group identity. Subsequent group formation activities encouraged sharing of experiences, connection building, and cohesion. By balancing multimodal art creation with social participation, the program promoted emotional bonding, mutual support, and trust, ultimately resulting in stable relationships and active engagement. Additional components included an art exhibition and digital sharing via WeChat to extend social benefits, while reflective interviews at program end explored participants' experiences and strategies for applying insights to daily life. Selected excerpts of participants' artworks are presented in Additional file 1: Figure S1.

Control group

The control group received usual care over the 14-week period, which encompassed assistance with daily living activities, basic medical care (including regular health check-ups and medication management), recreational activities, and environmental cleaning, with no additional structured intervention.

Outcomes

Primary outcome

Global cognitive function was assessed using the MoCA among older adults in China [43]. The cognitive domains evaluated include visuospatial and executive functions,

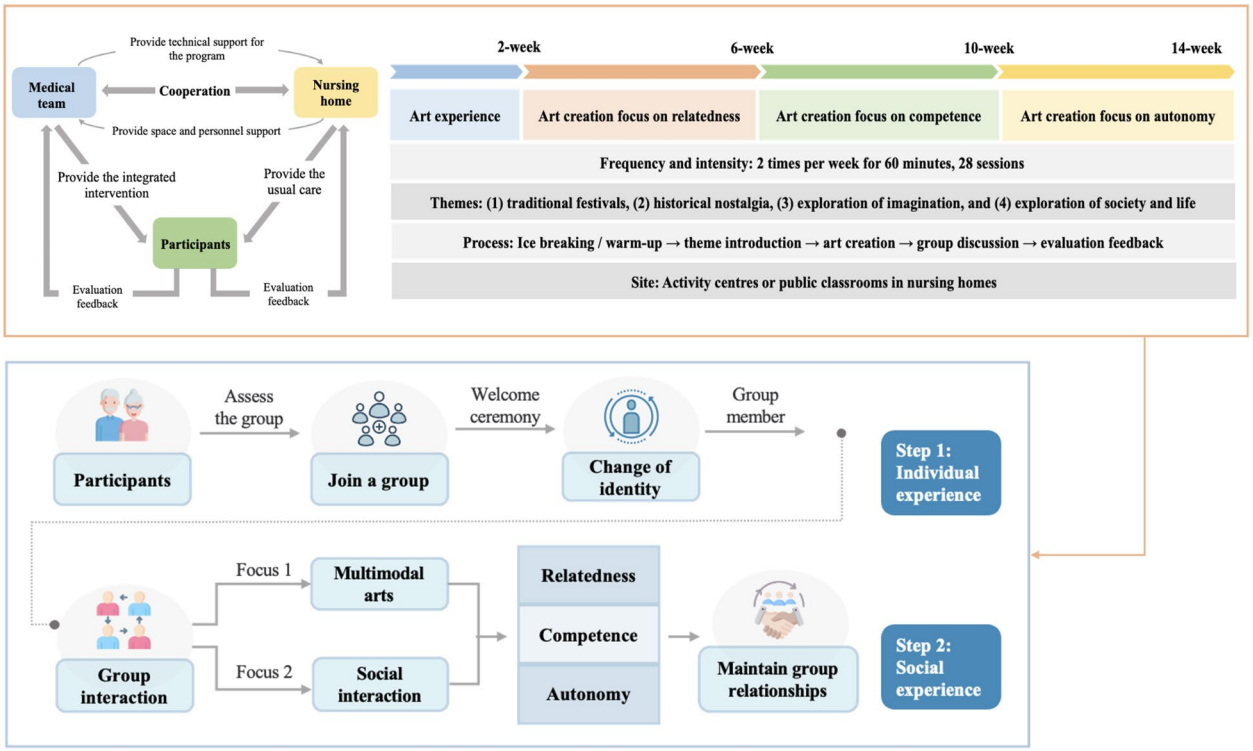

Fig. 1 The integrated intervention procedure

naming, memory, attention, language, abstract thinking, delayed recall, and orientation. Higher scores on the MoCA indicate better global cognitive function, with a sensitivity of 90% and a specificity of 87% [43].

Secondary outcomes

The secondary outcome measures included commonly used measures of specific cognitive domains, psychosocial indicators, functional abilities, and quality of life. A battery of neuropsychological tests was used to measure specific cognitive domains, including the Auditory Verbal Learning Test (AVLT) [44] for memory, the Shape Trail Test (STT) [45] for executive function, the Verbal Fluency Test (VFT) [46] and Boston Naming Test (BNT) [47] for language, and the Digit Span Test (DST) [48] for attention and working memory. Psychosocial indicators included psychological needs, social isolation, anxiety, depression, and subjective well-being. The Basic Psychological Needs Scales (BPNS) [49] was used to measure psychological needs, focusing on three dimensions: autonomy, competence, and relatedness, with higher scores indicating greater satisfaction. The Lubben Social Network Scale-6 (LSNS-6) [50] was used to evaluate social isolation, primarily measuring the number of family and friend contacts within a month, with lower scores indicating a higher risk of social isolation. Anxiety was assessed using the Zung Self-Assessment Anxiety Scale (SAS) [51], and depression was measured using the Geriatric Depression Scale-15 (GDS-15) [52], with higher scores indicating more severe symptoms. Subjective well-being was evaluated through the Memorial University of Newfoundland Scale of Happiness (MUNSH), with higher scores indicating higher levels of well-being [53]. Functional abilities were measured using the Activity of Daily Living (ADL) [54] and Functional Activities Questionnaire (FAQ) [55]. The ADL scale assessed basic and instrumental daily living activities, with higher scores indicating poorer abilities. The FAQ evaluated socially adaptive activities requiring complex cognitive engagement, with higher scores indicating poorer social activity capacity. The Quality of Life-Alzheimer's Disease (QoL-AD) [56] scale was used to comprehensively assess the individual's quality of life, including physical health, behavioral competence, psychological status, living environment, social relationships, and life satisfaction, with higher scores indicating better quality of life.

Data collection

Primary and secondary outcomes were assessed at baseline (T0), immediately post-intervention (T1), and at 24-week follow-up (T2) by blinded researchers. Attendance and adverse events were monitored throughout the intervention. The average attendance rate was calculated as the ratio of attended to total sessions.

Qualitative data were collected by the first author (a Master of Science in Nursing student) through face-to-face semi-structured interviews immediately post-intervention (T1). The interview guide was refined through pilot interviews with two older adults with MCI and expert feedback (Additional file 1: Table S4). Data collection continued until thematic saturation was reached (total $n = 15$). Interviews were conducted in private settings, avoiding meal, nap, and family visit times, with participants informed of their right to withdraw. Each interview, lasting 30–40 min, was audio-recorded with consent.

Data analysis

Quantitative analysis was performed using IBM SPSS (version 27.0.1.0). Descriptive statistics summarized baseline characteristics and outcome variables. Student's t test or Wilcoxon rank-sum test were used for continuous variables, and the chi-square test was used for categorical variables. Normality was assessed using skewness statistics (− 2 to 2) and Q-Q plots [57]. All randomly assigned participants were included in an intention-to-treat analysis [58].

Changes in outcomes between groups over time were analyzed using generalized estimating equations (GEE) [59], adjusted for age, sex, education, living status, and cluster. The correlation matrix was selected based on quasi-likelihood under the independence model criterion (QIC); a lower QIC value indicates a more optimal model [60]. GEE models provide consistent estimates under the assumption that data are missing at random [61]. Additionally, time and group variables, along with their interactions, were included in each model. Positively skewed variables were modeled with a gamma distribution and log link function [62], while normally distributed variables were analyzed with linear regression. Bonferroni correction was applied for multiple comparisons (adjusted $P < 0.05$).

Qualitative data were analyzed using descriptive content analysis with NVivo (version 12.0) [63]. Transcriptions were coded following a structured process [63]: familiarization, line-by-line coding, theme generation, iteration until saturation, and summarization. All data are securely stored in an electronic database established by the research team, with access granted only to internal researchers approved by the team leader.

Increase credibility of qualitative research

Rigor was ensured by adhering to credibility, dependability, confirmability, and transferability standards [64]. The first author, trained in qualitative methods, conducted all

interviews. Two researchers independently coded data, resolving discrepancies through discussion. Member checking ensured alignment with participants' perspectives. Memos and team discussions minimized bias, while detailed participant descriptions enhanced transferability (Additional file 1: Table S5).

Results

Baseline participant characteristics

Figure 2 shows the CONSORT flow diagram. A total of 12 potential nursing homes were screened for eligibility, of which 6 did not meet the inclusion criteria, and 2 declined due to lack of time or interest. Ultimately, four nursing homes were recruited and completed the study. In total, 80 participants from these four nursing homes were recruited for the study after providing informed consent and undergoing cognitive screening. These nursing homes were randomly assigned to either the intervention group ($n=$ 2, 40 participants) or the control group ($n=$ 2, 40 participants), and all participants were included in the data analysis. The median age of the participants was 86.50 years (range 82.75–90.00 years), they were predominantly female (71.25%), and most had a high school education or higher (65%). No significant differences in baseline characteristics were observed between the groups (Table 1). Of the 80 participants, 68 (35 in the intervention group and 33 in the control group) completed the 14-week assessments, and 61 (30 in the intervention group and 31 in the control group) completed the 24-week follow-up assessments. The dropout rates were 12.5% in the intervention group and 17.5% in the control group after the 14-week intervention. The main reasons for dropout included loss of contact due to moving away from the nursing home, withdrawal of informed consent, and health-related factors. Participants who completed the study differed significantly in VFT scores from those who withdrew (Additional file 1: Table S6). Additionally, the average attendance rate in the intervention group, accounting for dropouts, was 86.25% (966 out of 1120 sessions). No adverse events occurred during the intervention period.

Primary outcome

Tables 2 and 3 present the primary and secondary outcomes for both the intervention and control groups at three evaluation points (T0, T1, T2). Compared to the control group, the intervention group showed a significant improvement in MoCA scores from T0 to T1 ($\beta=$ 2.85; 95% CI [1.27, 4.44], $P<$ 0.001, adjusted), indicating enhanced global cognitive function at T1 (Table 3). Furthermore, the differences of the intervention group did not reach statistical significance at T2 ($\beta=$ 0.73; 95% CI [− 0.95, 2.40], $P=$ 0.396, adjusted).

Secondary outcomes

The intervention group showed demonstrated modest improvements in AVLT immediate recall and AVLT short-delay recall compared to the control group from T0 to T2; however, these changes did not reach statistical significance ($P>$ 0.05, Table 3). At T1, the intervention group showed a statistically significant decrease in STT-B from T0 ($\beta=-0.18$; 95% CI [− 0.29, − 0.08], $P=$ 0.001, Table 2). No statistically significant between-group differences were detected for specific cognitive domains, including AVLT long-delay recall, AVLT recognition, STT-A, VFT, BNT, and DST across the T0, T1, and T2 endpoints ($P>$ 0.05). Regarding BPNS competence, a significant group × time interaction effect was observed in the GEE model ($P=$ 0.011), indicating that changes over time were influenced by group assignment, although no significant differences existed between the groups (Table 3). Nonetheless, there was a significant upward trend in BPNS-competence scores from T0 to T1 in the intervention group ($P<$ 0.05; Table 2 and Fig. 3). Significant differences between the intervention and control groups were found in SAS and ADL scores from T0 to T1, with a delayed effect observed in MUNSH scores at T2. Conversely, no significant differences were observed in LSNS (including family and friends' dimensions), BPNS (including autonomy and relatedness dimensions), QoL-AD, GDS, and FAQ between groups across the time points (Table 3). Intra-group comparisons of primary and secondary outcomes based on the intention-to-treat analysis at different time points are presented in Additional file 1: Table S7. Results in this section are presented in accordance with the CONSORT 2010 statement checklist for reporting a randomized trial (Additional file 1: Table S8).

Qualitative findings

A total of 15 participants from the intervention program completed the qualitative interviews (mean age = 84.73). To explain the quantitative findings, three qualitative themes were developed: (i) short-term cognitive gains and their facilitating factors, (ii) barriers to long-term effect sustenance, and (iii) limitations in social interaction and functional transfer. The reporting follows the COREQ statement as shown in Additional file 1: Table S9.

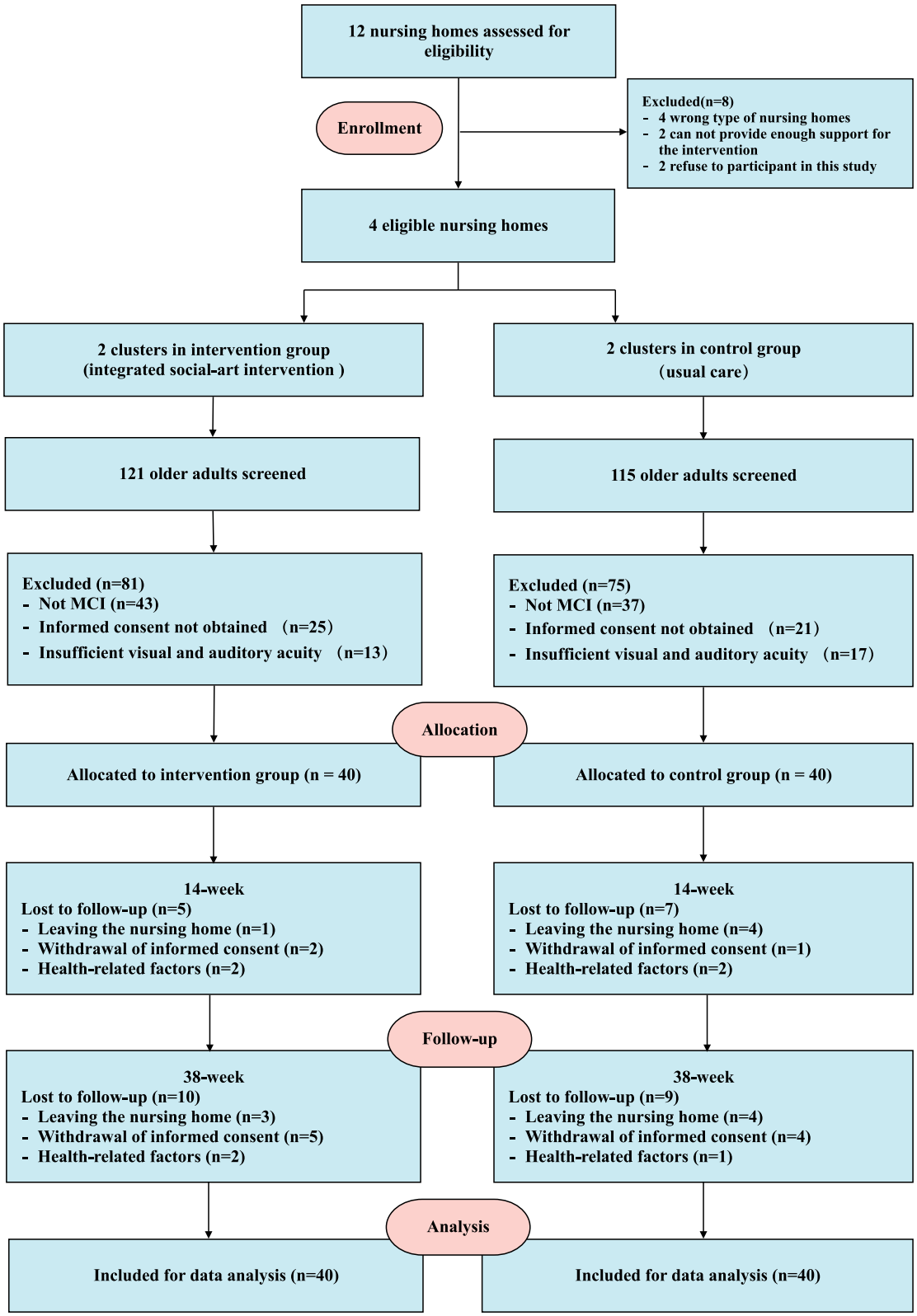

Fig. 2 CONSORT flow diagram

Table 1 Baseline demographic characteristics and outcome variables of the participants ($n = 80$)

Variables	Total ($n = 80$)	Intervention group ($n = 40$)	Control group ($n = 40$)	*P* value
Demographic characteristics				
Age (years)	86.50 (82.75, 90.00)	87.50 (83.75, 89.25)	85.00 (80.75, 90.00)	0.270[a]
Female	57 (71.25)	31 (77.50)	26 (65.00)	0.217[b]
Education level				0.510[b]
Elementary school or below	11 (13.75)	4 (10.00)	7 (17.50)	
Junior high school	17 (21.25)	10 (25.00)	7 (17.50)	
Senior high school or above	52 (65.00)	26 (65.00)	26 (65.00)	
Living status				0.499[b]
Single room	35 (43.75)	19 (47.50)	16 (40.00)	
Double room	45 (56.25)	21 (52.50)	24 (60.00)	
Family history of dementia	5 (6.25)	3 (7.50)	2 (5.00)	1.000[b]
Primary outcome				
MoCA	19.65 ± 3.25	19.63 ± 3.37	19.68 ± 3.17	0.946[c]
Secondary outcomes				
AVLT immediate recall	12.44 ± 4.52	12.95 ± 5.00	11.93 ± 3.98	0.313[c]
AVLT short-delay recall	3 (1.00, 4.25)	3 (1.00, 5.00)	3 (1.00, 4.00)	0.693[a]
AVLT long-delay recall	2.50 (0.00, 4.00)	3 (0.75, 4.00)	2 (0.00, 4.00)	0.357[a]
AVLT recognition	18.58 ± 3.46	18.85 ± 3.53	18.30 ± 3.41	0.481[c]
STT-A	94.50 (69.75, 113.25)	96.50 (71.75, 112.25)	89.50 (63.75, 114.50)	0.473[a]
STT-B	210 (180.00, 264.75)	193 (159.75, 260.75)	219.50 (195.00, 308.25)	0.057[a]
VFT	13.50 ± 3.00	13.60 ± 3.33	13.40 ± 2.68	0.768[c]
DST	11.50 ± 1.85	11.55 ± 1.77	11.45 ± 1.95	0.811[c]
BNT	18.27 ± 4.36	18.05 ± 4.47	18.50 ± 4.30	0.648[c]
LSNS	14.31 ± 6.47	13.20 ± 5.41	15.43 ± 7.28	0.125[c]
LSNS-family	8.16 ± 3.47	7.88 ± 3.36	8.45 ± 3.60	0.463[c]
LSNS-friend	6 (4.00, 9.00)	6 (4.00, 8.00)	7 (4.00, 9.25)	0.088[a]
BPNS	120 (105.25, 128.25)	125.50 (106.75, 132.25)	115.50 (105.25, 124.75)	0.116[a]
BPNS-autonomy	42 (36.75, 45.00)	43.50 (37.75, 46.00)	41 (36.00, 45.00)	0.236[a]
BPNS-competence	30.05 ± 6.83	30.53 ± 7.01	29.58 ± 6.69	0.537[c]
BPNS-related	47.50 (42.00, 53.00)	49.50 (42.75, 54.00)	45.50 (41.75, 51.25)	0.156[a]
GDS	1 (0.00, 4.00)	1 (0.00, 3.00)	1 (0.00, 4.00)	0.748[a]
SAS	28 (25.00, 34.50)	28 (25.00, 31.75)	30 (26.00, 36.00)	0.408[a]
MUNSH	18 (13.00, 22.25)	18 (12.75, 22.00)	19 (13.00, 23.00)	0.572[a]
ADL	22 (20.00, 25.00)	23 (20.00, 25.00)	20 (20.00, 24.00)	0.104[a]
FAQ	0 (0.00, 2.00)	1 (0.00, 2.00)	0 (0.00, 3.00)	0.752[a]
QoL-AD	30 (27.00, 35.00)	29 (27.75, 34.00)	31.50 (27.00, 37.00)	0.079[a]

MoCA Montreal Cognitive Assessment, *AVLT* Auditory Verbal Learning Test, *STT* Shape Trail Test, *VFT* Verbal Fluency Test, *DST* Digit Span Test, *BNT* Boston Naming Test, *LSNS* Lubben Social Network Scale, *BPNS* Basic Psychological Needs Scales, *GDS* Geriatric Depression Scale, *SAS* Self-Rating Anxiety Scale, *MUNSH* Memorial University of Newfoundland Scale of Happiness, *ADL* Activity of Daily Living, *FAQ* Functional Activities Questionnaire, *QoL* Quality of life-Alzheimer's disease. Data are presented as the mean ± SD or median (Q1, Q3) for continuous variables and numbers (%) for categorical variables

[a] Mann-Whitney test

[b] Pearson c^2 test

[c] *t*-test

Theme 1: short-term cognitive gains and their facilitating factors

Subtheme 1.1: Task-induced cognitive activation.

Participants reported that the structured, sequential tasks (e.g., stepwise art creation) activated cognitive processes—such as working memory and attention—that likely drove the T1 MoCA improvements.

"Engaging consistently in these activities has imbued me with a sense of elevated cerebral functioning. The regular activation of both mental and physical faculties has been crucial in enhancing my brain's cognitive abilities..." (P1, 90–94 years old).

Table 2 Summary of changes in primary and secondary outcomes between groups at different time points

Outcome	Intervention group			Control group			Mean difference between groups	
	Mean (SD)/ Median (Q1, Q3)	Within-group change from baseline (95%CI)	*P* value	Mean (SD)/ Median (Q1, Q3)	Within-group change from baseline (95%CI)	*P* value	*t/H*	*P* value
Global cognitive function (MoCA)								
T0	19.63 (3.37)	NA	NA	19.68 (3.17)	NA	NA	0.068	0.946
T1	22.34 (3.63)	2.67 (1.56, 3.79)	< 0.001	19.61 (4.30)	− 0.14 (− 1.26, 0.98)	0.810	− 2.842	0.006
T2	20.87 (3.57)	1.31 (0.14, 2.49)	0.029	20.35 (3.50)	0.65 (− 0.54, 1.83)	0.287	− 0.566	0.574
Specific cognitive domains								
Memory domain (AVLT)								
AVLT immediate recall								
T0	12.95 (5.00)	NA	NA	11.93 (3.98)	NA	NA	− 1.015	0.313
T1	15.69 (6.60)	2.81 (0.96, 4.67)	0.003	13.27 (4.21)	1.30 (− 0.11, 2.70)	0.070	− 1.786	0.079
T2	15.47 (7.36)	2.82 (0.46, 5.18)	0.019	13.87 (4.67)	1.85 (0.38, 3.33)	0.014	− 1.015	0.314
AVLT short-delay recall								
T0	3 (1.00, 5.00)	NA	NA	3 (1.00, 4.00)	NA	NA	0.156	0.693
T1	3 (1.00, 5.00)	0.51 (− 0.35,1.36)	0.244	3 (2.00, 5.00)	0.45 (− 0.26,1.15)	0.212	0.002	0.965
T2	4 (2.00, 5.75)	1.15 (0.24, 2.07)	0.014	3 (2.00, 4.25)	0.65 (− 0.26,1.55)	0.160	0.585	0.444
AVLT long-delay recall								
T0	3 (0.75, 4.00)	NA	NA	2 (0.00, 4.00)	NA	NA	0.847	0.357
T1	3 (0.00, 5.00)	0.50 (− 0.30,1.30)	0.219	3 (1.00, 4.00)	0.52 (− 0.18,1.22)	0.146	0.229	0.632
T2	3 (1.00, 5.00)	0.30 (− 0.51,1.10)	0.472	3 (0.75, 4.00)	0.56 (− 0.32,1.43)	0.211	0.113	0.737
AVLT recognition								
T0	18.85 (3.53)	NA	NA	18.30 (3.41)	NA	NA	− 0.709	0.481
T1	19.31 (3.41)	0.41 (− 0.50,1.32)	0.373	18.85 (3.55)	0.55 (− 0.51,1.62)	0.310	− 0.551	0.583
T2	18.10 (6.37)	− 0.73 (− 2.84,1.39)	0.500	18.90 (5.47)	0.48 (− 1.63,2.58)	0.658	0.529	0.599
Executive domain (STT)								
STT-A								
T0	96.50 (71.75, 112.25)	NA	NA	89.50 (63.75, 114.50)	NA	NA	0.514	0.473
T1	85 (60.00, 120.00)	− 0.06 (− 0.16, 0.03)	0.203	98 (56.50, 130.00)	0.07 (− 0.06,0.21)	0.292	0.201	0.6564
T2	99 (67.50, 120.00)	0.02 (− 0.12, 0.16)	0.799	93 (70.25, 120.00)	0.16 (− 0.001,0.33)	0.051	0.026	0.871
STT-B								
T0	193 (159.75, 260.75)	NA	NA	219.50 (195.00, 308.25)	NA	NA	3.613	0.057
T1	180 (148.00, 207.00)	− 0.18 (− 0.29, − 0.08)	0.001	195 (143.50, 244.00)	− 0.16 (− 0.34,0.03)	0.092	0.473	0.492
T2	211 (156.00, 269.75)	0.03 (− 0.10, 0.16)	0.659	180 (138.25, 201.25)	− 0.22 (− 0.38, − 0.06)	0.006	3.916	0.048
Language domain (VFT and BNT)								
VFT								
T0	13.60 (3.33)	NA	NA	13.40 (2.68)	NA	NA	− 0.296	0.768
T1	14.54 (3.29)	0.92 (− 0.30, 2.15)	0.139	14.36 (3.41)	0.99 (−0.26, 2.25)	0.121	− 0.221	0.826
T2	12.97 (3.58)	− 0.62 (− 1.98, 0.74)	0.375	14.19 (2.99)	0.63 (− 0.78, 2.05)	0.383	1.455	0.151
BNT								
T0	18.05 (4.47)	NA	NA	18.50 (4.30)	NA	NA	0.459	0.648
T1	18.94 (4.52)	0.84 (−0.20, 1.88)	0.111	18.55 (5.24)	− 0.08 (− 1.30,1.14)	0.899	− 0.335	0.738
T2	19.43 (3.87)	1.43 (0.11, 2.75)	0.034	19.39 (4.26)	1.02 (− 0.37, 2.41)	0.149	− 0.044	0.965
Attention domain (DST)								
T0	11.55 (1.77)	NA	NA	11.45 (1.95)	NA	NA	− 0.240	0.811
T1	11.46 (1.99)	− 0.06 (− 0.69, 0.57)	0.843	11.09 (2.23)	− 0.40 (− 1.10, 0.30)	0.267	− 0.716	0.477
T2	11.47 (1.85)	− 0.01 (− 0.59, 0.57)	0.973	11.97 (1.76)	0.42 (− 0.21, 1.06)	0.189	1.083	0.283
Psychosocial domains								
LSNS								
T0	13.20 (5.41)	NA	NA	15.43 (7.28)	NA	NA	1.552	0.125

Table 2 (continued)

Outcome	Intervention group			Control group			Mean difference between groups	
	Mean (SD)/ Median (Q1, Q3)	Within-group change from baseline (95%CI)	*P* value	Mean (SD)/ Median (Q1, Q3)	Within-group change from baseline (95%CI)	*P* value	*t/H*	*P* value
T1	13.34 (5.69)	0.16 (– 1.55, 1.88)	0.852	14.58 (6.93)	– 0.91 (– 3.43, 1.61)	0.477	0.804	0.424
T2	13.47 (6.80)	0.32 (– 1.95, 2.58)	0.785	15.19 (6.45)	– 0.67 (– 3.07, 1.73)	0.583	1.018	0.313
LSNS-family								
T0	7.88 (3.36)	NA	NA	8.45 (3.60)	NA	NA	0.738	0.463
T1	7.94 (2.88)	0.06 (– 0.88, 1.00)	0.903	8.58 (3.83)	0.10 (– 1.20, 1.40)	0.883	0.773	0.442
T2	7.14 (3.63)	– 0.76 (– 2.06, 0.54)	0.250	8.19 (3.14)	– 0.45 (– 1.53, 0.62)	0.411	1.207	0.232
LSNS-friend								
T0	6 (4.00, 8.00)	NA	NA	7 (4.00, 9.25)	NA	NA	2.918	0.088
T1	6 (2.00, 8.00)	0.06 (– 1.13, 1.24)	0.927	6 (2.00, 9.00)	– 1.51 (– 3.08, 0.07)	0.061	0.015	0.902
T2	5.5 (3.00, 10.00)	1.13 (– 0.41, 2.67)	0.150	6.5 (3.00, 12.00)	– 0.21 (– 1.99, 1.58)	0.821	0.311	0.577
BPNS								
T0	125.50 (104.25, 132.75)	NA	NA	115.50 (103.75, 126.25)	NA	NA	2.492	0.114
T1	127.00 (113.00, 136.00)	2.66 (– 3.11, 8.43)		119.00 (108.00, 127.50)	4.78 (– 1.73, 11.29)	0.150	2.450	0.117
T2	121.00 (99.50, 130.00)	– 3.99 (– 11.83, 3.85)	0.319	118.00 (111.00, 129.00)	– 3.86 (– 2.92,10.64)	0.264	0.241	0.624
BPNS-autonomy								
T0	43.50 (37.75, 46.00)	NA	NA	41 (36.00, 45.00)	NA	NA	1.407	0.236
T1	43 (37.00, 46.00)	0.25 (– 1.79, 2.30)	0.811	43 (38.00, 45.00)	2.60 (– 0.01, 5.20)	0.051	0.004	0.951
T2	41.5 (33.25, 45.00)	– 2.10 (– 4.89, 0.68)	0.138	40.5 (34.00, 44.25)	– 0.63 (– 3.27, 2.01)	0.640	< 0.001	0.994
BPNS-competence								
T0	30.53 (7.01)	NA	NA	29.58 (6.69)	NA	NA	– 0.620	0.537
T1	32.51 (5.68)	1.92 (– 0.31, 4.15)	0.092	29.03 (6.15)	– 0.54 (– 2.72, 1.65)	0.629	– 2.428	0.018
T2	32.17 (5.39)	1.72 (– 0.98, 4.43)	0.212	33.61 (5.17)	3.85 (1.29, 6.41)	0.003	1.070	0.289
BPNS-related								
T0	49.50 (42.75, 54.00)	NA	NA	45.50 (41.75, 51.25)	NA	NA	2.009	0.156
T1	50 (45.00, 54.00)	0.78 (– 1.63, 3.19)	0.525	48 (44.00, 51.50)	2.52 (– 0.21, 5.25)	0.070	1.106	0.293
T2	46.5 (40.25, 50.00)	– 2.95 (– 5.95, 0.05)	0.054	46.5 (42.00, 50.00)	0.28 (– 2.81, 3.38)	0.857	0.176	0.675
SAS								
T0	28 (25.00, 31.75)	NA	NA	30 (26.00, 36.00)	NA	NA	0.684	0.408
T1	30 (26.00, 36.00)	0.10 (0.02, 0.18)	0.021	28 (25.00, 32.00)	– 0.08 (– 0.17, 0.01)	0.078	2.761	0.097
T2	32.5 (31.00, 40.00)	0.17 (0.10, 0.25)	0.001	28 (26.75, 37.00)	0.06 (– 0.06, 0.18)	0.346	3.348	0.067
GDS								
T0	1 (0.00, 3.00)	NA	NA	1 (0.00, 4.00)	NA	NA	0.103	0.748
T1	2 (1.00, 4.00)	0.52 (– 0.36, 1.40)	0.245	2 (0.00, 4.00)	– 0.45 (– 1.48, 0.57)	0.387	0.506	0.477
T2	3 (1.00, 5.00)	1.47 (0.40, 2.55)	0.007	2 (1.00, 4.00)	1.12 (0.02, 2.21)	0.046	0.295	0.587
MUNSH								
T0	18 (12.75, 22.00)	NA	NA	19 (13.00, 23.00)	NA	NA	0.319	0.572
T1	19 (12.00, 22.00)	0.47 (– 1.94, 2.88)	0.703	18 (12.50, 22.00)	1.78 (– 1.32, 4.88)	0.261	0.001	0.971
T2	15 (4.25, 21.00)	– 3.78 (– 7.42, – 0.15)	0.042	20.5 (15.75, 22.00)	2.27 (– 0.55, 5.09)	0.115	5.155	0.023
Daily and social abilities								
ADL								
T0	23 (20.00, 25.00)	NA	NA	20 (20.00, 24.00)	NA	NA	2.637	0.104
T1	22 (21.00, 26.00)	0.04 (– 1.15, 1.22)	0.953	23 (20.50, 29.50)	2.80 (1.09, 4.51)	0.001	0.978	0.323
T2	22.5 (20.25, 24.00)	– 0.27 (– 1.92, 1.37)	0.745	20 (20.00, 26.50)	1.96 (0.07, 3.85)	0.042	1.289	0.256
FAQ								
T0	1 (0.00, 2.00)	NA	NA	0 (0.00, 3.00)	NA	NA	0.100	0.752
T1	1 (0.00, 2.00)	– 0.09 (– 0.38, 0.19)	0.523	0 (0.00, 2.00)	– 0.38 (– 0.90, 0.13)	0.143	2.057	0.151
T2	2 (0.00, 2.75)	– 0.05 (– 0.51, 0.41)	0.832	1 (0.00, 3.00)	– 0.06 (– 0.47, 0.36)	0.784	0.276	0.599

Table 2 (continued)

Outcome	Intervention group			Control group			Mean difference between groups	
	Mean (SD)/ Median (Q1, Q3)	Within-group change from baseline (95%CI)	*P* value	Mean (SD)/ Median (Q1, Q3)	Within-group change from baseline (95%CI)	*P* value	*t/H*	*P* value
Quality of life (QoL-AD)								
T0	29 (27.75, 34.00)	NA	NA	31.50 (27.00, 37.00)	NA	NA	3.080	0.079
T1	31 (26.00, 33.00)	0.09 (− 0.05, 0.23)	0.222	29 (26.00, 33.50)	− 0.08 (− 0.15, − 0.02)	0.017	0.433	0.510
T2	30 (24.25, 35.00)	− 0.01 (− 0.08, 0.05)	0.683	33.5 (26.00, 38.25)	0.02 (− 0.07, 0.10)	0.737	3.449	0.063

Abbreviations SD Standard Deviation, *CI* Confidence Interval, *NA* Not Applicable, *T0* Baseline, *T1* 14-week, *T2* 24-week follow-up, *MoCA* Montreal Cognitive Assessment, *AVLT* Auditory Verbal Learning Test, *STT* Shape Trail Test, *VFT* Verbal Fluency Test, *BNT* Boston Naming Test, *DST* Digit Span Test, *LSNS* Lubben Social Network Scale, *BPNS* Basic Psychological Needs Scales, *SAS* Self-Rating Anxiety Scale, *GDS* Geriatric Depression Scale, *MUNSH* Memorial University of Newfoundland Scale of Happiness, *ADL* Activity of Daily Living, *FAQ* Functional Activities Questionnaire, *QoL* Quality of life-Alzheimer's disease. Bold data indicates $P < 0.05$

"I've also noticed a significant improvement in my memory. Each activity presents new challenges that require memorizing steps, which really stimulates the mind, doesn't it?" (P5, 90–94 years old).

Subtheme 1.2: Program design appropriateness.

The intervention's well-structured design and the tangible outcomes it delivered contributed to participants' short-term gains.

"This program is quite stable, and it's short. The finished product offers tangible outcomes, making me feel very accomplished." (P15, 80–84 years old).

Subtheme 1.3: Professional guidance.

The presence of skilled facilitators provided essential support that enhanced cognitive engagement during the sessions.

"To be honest, if we had to manage on our own without professional guidance, it would likely be much more challenging. With your patience and support, we felt confident in completing it properly." (P2, 85–89 years old).

Theme 2: barriers to long-term effect sustenance

Subtheme 2.1: Comorbidity-driven participation fragmentation.

Age-related physical decline and chronic health issues disrupted continuous engagement with the intervention, likely diluting the cumulative benefits.

"The main factor is my age; my body no longer functions as it used to. I now move cautiously, walking slowly and deliberately, avoiding haste, unlike in the past when I could move more briskly." (P1, 90–94 years old).

"Due to health reasons, I undergo regular physiotherapy, which sometimes conflicts with the class schedule. Despite this, I make every effort to catch up on missed sessions." (P14, 85–89 years old).

Subtheme 2.2: Psychological and role transition challenges.

Several participants described feelings of helplessness and diminished self-worth after retirement, which reduced their motivation to continue participating.

"I constantly feel that aging has made me quite helpless. I can't accomplish tasks independently and require guidance to understand." (P11, 85–89 years old).

"I perceive myself as being on the periphery of life's stages at this advanced age, which fosters a sense of futility in learning new things, making such pursuits seem superfluous." (P9, 85–89 years old).

Theme 3: limitations in social interaction and functional transfer

Subtheme 3.1: Intervention-locked social interaction.

Social engagement was confined to the sessions, with peer support occurring sporadically and lacking a structured mechanism for continuity. Despite camaraderie during activities, these connections did not extend beyond the intervention, limiting long-term psychosocial benefits.

"We encouraged each other in class, but there's no system to sustain contact afterward." (P2, 85–89 years old).

"Group support helped me complete tasks here, but I still eat meals alone." (P8, 75–79 years old).

Table 3 Primary and secondary outcomes differences between both groups across time points according to the GEE analysis

	Unadjusted model				Adjusted model[a]			
	Group × Time interaction effect	*β*	95% CI	*P* value	Group × Time interaction effect	*β*	95% CI	*P* value
Global cognitive function (MoCA)	0.002				0.002			
Group		− 0.05	− 1.47, 1.37	0.945		− 1.43	− 4.07, 1.22	0.291
T1		− 0.07	− 1.20, 1.06	0.905		− 0.15	− 1.27, 0.98	0.800
T2		0.68	− 0.58, 1.94	0.289		0.60	− 0.58, 1.78	0.321
Group * T1		2.79	1.20, 4.37	< 0.001		2.85	1.27,4.44	< 0.001
Group * T2		0.56	− 1.17, 2.29	0.525		0.73	− 0.95, 2.40	0.396
Specific cognitive domains								
Memory domain (AVLT)								
AVLT immediate recall	0.481				0.415			
Group		1.03	− 0.93, 2.98	0.304		− 0.82	− 4.90, 3.27	0.696
T1		1.35	−.04, 2.74	0.057		1.31	− 0.10, 2.72	0.068
T2		1.95	0.41, 3.49	0.013		1.72	0.20, 3.23	0.027
Group * T1		1.39	− 0.90, 3.68	0.234		1.53	−.74, 3.80	0.186
Group * T2		0.57	− 2.22, 3.36	0.689		1.09	− 1.74, 3.92	0.451
AVLT short-delay recall	0.808				0.652			
Group		0.30	− 0.70, 1.30	0.557		0.03	− 2.11, 2.18	0.977
T1		0.46	− 0.23, 1.14	0.189		0.45	− 0.24, 1.13	0.202
T2		0.71	− 0.21, 1.62	0.131		0.62	− 0.28, 1.53	0.177
Group * T1		0.02	− 1.06, 1.11	0.966		0.07	− 0.10, 1.13	0.902
Group * T2		0.35	− 0.93, 1.64	0.590		0.52	− 0.77, 1.81	0.429
AVLT long-delay recall	0.758				0.894			
Group		0.58	− 0.40, 1.55	0.248		− 0.06	− 2.13, 2.01	0.955
T1		0.51	− 0.17, 1.20	0.143		0.52	− 0.17, 1.21	0.142
T2		0.60	− 0.29, 1.48	0.187		0.51	− 0.35, 1.37	0.247
Group * T1		− 0.02	− 1.08, 1.04	0.970		0.01	− 1.03, 1.06	0.978

Table 3 (continued)

	Unadjusted model				Adjusted model[a]			
	Group × Time interaction effect	β	95% CI	*P* value	Group × Time interaction effect	β	95% CI	*P* value
Group * T2		− 0.38	− 1.56, 0.80	0.528		− 0.22	− 1.40, 0.95	0.711
AVLT recognition	0.677				0.758			
Group		0.55	− 0.95, 2.05	0.473		− 1.17	− 4.29, 1.94	0.461
T1		0.55	− 0.53, 1.63	0.318		0.51	−.56, 1.59	0.349
T2		0.60	− 1.53, 2.74	0.580		0.49	− 1.66, 2.64	0.656
Group * T1		− 0.08	− 1.48, 1.31	0.906		− 0.03	− 1.43, 1.37	0.970
Group * T2		− 1.35	− 4.38, 1.67	0.381		− 1.13	− 4.20, 1.93	0.469
Executive domain (STT)								
STT-A	0.351				0.298			
Group		0.03	− 0.13, 0.18	0.743		− 0.08	− 0.48, 0.33	0.714
T1		0.08	− 0.07, 0.23	0.293		0.08	− 0.07, 0.22	0.320
T2		0.17	− 0.02, 0.36	0.086		0.19	− 0.001, 0.37	0.052
Group * T1		− 0.13	− 0.31, 0.05	0.150		− 0.13	− 0.30, 0.05	0.155
Group * T2		− 0.12	− 0.37, 0.14	0.372		− 0.15	− 0.39, 0.08	0.199
STT-B	0.002				0.007			
Group		− 0.14	− 0.29, 0.01	0.076		− 0.23	− 0.59, 0.14	0.221
T1		− 0.15	− 0.35, 0.05	0.141		− 0.16	− 0.35, 0.03	0.108
T2		− 0.22	− 0.40, − 0.04	0.018		− 0.21	− 0.38, − 0.04	0.018
Group * T1		− 0.03	− 0.25, 0.19	0.803		− 0.03	− 0.24, 0.19	0.821
Group * T2		0.26	0.04, 0.48	0.023		0.23	0.02, 0.44	0.035
Language domain (VFT and BNT)								
VFT	0.185				0.209			
Group		0.20	− 1.11, 1.51	0.764		1.59	− 1.03, 4.22	0.234
T1		0.96	− 0.31, 2.24	0.138		0.92	−.35, 2.19	0.157
T2		0.79	− 0.61, 2.20	0.269		0.75	− 0.64, 2.15	0.291
Group * T1		− 0.02	− 1.79, 1.75	0.982		0.03	− 1.74, 1.80	0.973
Group * T2		− 1.43	− 3.39, 0.54	0.154		− 1.34	− 3.30, 0.62	0.181
BNT	0.582				0.575			

Table 3 (continued)

	Unadjusted model				Adjusted model[a]			
	Group × Time interaction effect	β	95% CI	*P* value	Group × Time interaction effect	β	95% CI	*P* value
Group		− 0.45	− 2.35, 1.45	0.642		− 4.53	− 8.01, − 1.05	0.011
T1		0.05	− 1.18, 1.28	0.942		− 0.04	− 1.25, 1.17	0.952
T2		0.89	− 0.67, 2.44	0.264		0.84	− 0.56, 2.24	0.238
Group * T1		0.85	− 0.76, 2.46	0.302		0.85	− 0.75, 2.45	0.298
Group * T2		0.50	− 1.56, 2.55	0.636		0.58	− 1.36, 2.52	0.560
Attention domain (DST)	0.255				0.297			
Group		0.10	−.71, 0.91	0.808		0.02	− 1.33, 1.37	0.982
T1		− 0.36	− 1.06, 0.34	0.317		− 0.39	− 1.09, 0.32	0.282
T2		0.52	− 0.15, 1.18	0.128		0.47	− 0.15, 1.10	0.139
Group * T1		0.27	− 0.67, 1.20	0.578		0.31	− 0.64, 1.25	0.525
Group * T2		− 0.60	− 1.48, 0.28	0.181		− 0.50	− 1.35, 0.36	0.256
Psychosocial domains								
LSNS	0.819				0.731			
Group		− 2.23	− 5.00, 0.55	0.116		1.45	− 3.49, 6.39	0.566
T1		− 0.85	− 3.38, 1.68	0.511		− 0.95	− 3.45, 1.54	0.454
T2		− 0.23	− 2.62, 2.15	0.849		− 0.41	− 2.81, 2.00	0.741
Group * T1		0.99	− 2.09, 4.07	0.528		1.21	− 1.83, 4.25	0.435
Group * T2		0.50	− 2.85, 3.84	0.770		0.88	− 2.43, 4.19	0.601
LSNS-family	0.840				0.887			
Group		− 0.58	− 2.08, 0.93	0.455		0.45	− 2.27, 3.16	0.747
T1		0.13	− 1.17, 1.42	0.849		0.10	− 1.20, 1.40	0.886
T2		− 0.26	− 1.32, 0.81	0.637		− 0.29	− 1.36, 0.77	0.590
Group * T1		− 0.06	− 1.66, 1.54	0.944		0.00	− 1.60, 1.61	0.996
Group * T2		− 0.48	− 2.20, 1.24	0.585		− 0.37	− 2.05, 1.32	0.672
LSNS-friend	0.337				0.245			
Group		− 1.60	− 3.25, 0.05	0.057		0.77	− 2.21, 3.75	0.612
T1		− 1.46	− 3.06, 0.14	0.074		− 1.53	− 3.10, 0.04	0.055
T2		0.03	− 1.80, 1.85	0.979		− 0.11	− 1.93, 1.71	0.905
Group * T1		1.49	− 0.52, 3.49	0.147		1.64	− 0.34, 3.61	0.104
Group * T2		1.05	− 1.36, 3.46	0.394		1.30	− 1.08, 3.67	0.285

Table 3 (continued)

	Unadjusted model				Adjusted model[a]			
	Group × Time interaction effect	*β*	95% CI	*P* value	Group × Time interaction effect	*β*	95% CI	*P* value
BPNS	0.171				0.165			
Group		5.68	− 3.12, 14.47	0.206		5.68	− 8.56, 19.91	0.434
T1		4.84	− 1.83, 11.52	0.155		4.49	− 2.09, 11.06	0.181
T2		4.43	− 2.45, 11.32	0.207		4.62	− 2.10, 11.34	0.178
Group * T1		− 1.89	− 10.68, 6.91	0.675		− 1.65	− 10.44, 7.14	0.712
Group * T2		− 8.60	− 18.90, 1.70	0.102		− 8.61	− 18.91, 1.69	0.101
BPNS-autonomy	0.440				0.456			
Group		1.50	− 1.81, 4.82	0.375		1.02	− 4.37, 6.41	0.711
T1		2.56	− 0.12, 5.25	0.061		2.44	− 0.21, 5.08	0.071
T2		− 0.50	− 3.16, 2.15	0.709		− 0.42	− 3.01, 2.18	0.754
Group * T1		− 2.18	− 5.53, 1.16	0.201		− 2.13	− 5.48, 1.22	0.214
Group * T2		− 1.70	− 5.48, 2.07	0.376		− 1.76	− 5.53, 2.01	0.361
BPNS-competence	0.011				0.011			
Group		0.95	− 2.02, 3.92	0.530		− 0.19	− 5.38, 5.00	0.943
T1		− 0.55	− 2.83, 1.74	0.640		− 0.64	− 2.86, 1.58	0.572
T2		4.04	1.58, 6.49	0.001		4.12	1.65, 6.59	0.001
Group * T1		2.53	− 0.64, 5.71	0.118		2.57	− 0.58, 5.72	0.110
Group * T2		− 2.40	− 6.01, 1.22	0.194		− 2.44	− 6.11, 1.22	0.191
BPNS-related	0.305				0.295			
Group		2.70	− 0.86, 6.26	0.137		4.12	− 1.12, 9.36	0.123
T1		2.58	− 0.11, 5.26	0.060		2.46	− 0.24, 5.16	0.074
T2		0.51	− 2.78, 3.80	0.760		0.56	− 2.63, 3.76	0.731
Group * T1		− 1.67	− 5.26, 1.93	0.363		− 1.56	− 5.19, 2.08	0.401
Group * T2		− 3.45	− 7.9, 0.99	0.127		− 3.41	− 7.79, 0.97	0.127
SAS	0.012				0.013			
Group		− 0.09	− 0.15, 0.07	0.441		0.05	− 0.41, − 0.01	0.043
T1		− 0.08	− 0.17, 0.003	0.059		− 0.08	− 0.17, 0.01	0.063
T2		0.02	− 0.07, 0.17	0.422		0.03	− 0.08, 0.17	0.439
Group * T1		0.19	0.06, 0.30	0.004		0.18	0.06, 0.30	0.004
Group * T2		− 0.03	− 0.02, 0.28	0.087		− 0.04	− 0.02, 0.28	0.092

Table 3 (continued)

	Unadjusted model				Adjusted model[a]			
	Group × Time interaction effect	***β***	**95% CI**	***P* value**	**Group × Time interaction effect**	***β***	**95% CI**	***P* value**
GDS	0.430				0.460			
Group		− 0.04	− 1.51, 1.01	0.696		− 0.21	− 4.34, − 0.05	0.045
T1		− 0.08	− 1.45, 0.62	0.432		− 0.08	− 1.41, 0.64	0.466
T2		0.05	− 0.09, 1.98	0.074		0.05	− 0.10, 2.00	0.077
Group * T1		0.18	− 0.47, 2.22	0.201		0.18	− 0.51, 2.19	0.221
Group * T2		0.13	− 0.94, 2.00	0.478		0.13	− 0.96, 2.01	0.486
MUNSH	0.009				0.004			
Group		− 0.25	− 5.14, 3.94	0.796		− 2.20	− 4.54, 9.55	0.486
T1		− 0.41	− 1.48, 4.86	0.296		− 0.38	− 1.60, 4.73	0.332
T2		0.94	− 0.47, 5.07	0.103		0.95	− 0.23, 5.29	0.072
Group * T1		0.88	− 4.88, 2.94	0.627		0.84	− 4.96, 2.96	0.621
Group * T2		0.53	− 10.50, − 1.52	0.009		0.53	− 10.92, − 1.95	0.005
Daily and social abilities								
ADL	0.033				0.028			
Group		0.68	− 1.06, 2.41	0.447		0.70	− 3.26, 4.66	0.729
T1		2.76	1.01, 4.50	0.002		2.77	1.07, 4.47	0.001
T2		1.38	− 0.66, 3.41	0.186		1.52	−.52, 3.56	0.145
Group * T1		− 2.74	− 4.85, − 0.62	0.011		− 2.79	− 4.89, − 0.70	0.009
Group * T2		− 1.67	− 4.28, 0.94	0.210		− 1.82	− 4.43, 0.79	0.171
FAQ	0.140				0.156			
Group		− 0.45	− 1.73, 0.83	0.490		− 0.84	− 3.31, 1.63	0.503
T1		− 0.79	− 1.53 − 0.05	0.035		− 0.77	− 1.54, 0.001	0.050
T2		0.09	− 1.12, 1.30	0.885		0.16	−.977, 1.29	0.784
Group * T1		0.04	− 0.15, 1.78	0.100		0.78	− 0.21, 1.76	0.122
Group * T2		0.15	− 1.35, 1.66	0.843		0.06	− 1.38, 1.50	0.937
Quality of life (QoL-AD)	0.073				0.058			
Group		− 0.60	− 0.18, − 0.01	0.038		2.51	− 0.16, 0.26	0.612
T1		1.69	− 0.15, − 0.01	0.019		1.57	− 0.15, 0−.02	0.017
T2		2.30	− 0.06, 0.11	0.592		2.53	− 0.06, 0.11	0.539
Group * T1		− 0.97	0.002, 0.38	0.048		− 1.00	0.01, 0.36	0.040

Table 3 (continued)

	Unadjusted model				Adjusted model[a]			
	Group × Time interaction effect	***β***	**95% CI**	***P* value**	**Group × Time interaction effect**	***β***	**95% CI**	***P* value**
Group * T2		− 6.02	− 0.14, 0.08	0.577		− 6.43	− 0.15, 0.07	0.476

Abbreviations β Regression Coefficient, *CI* Confidence Interval, *T1* 14-week, *T2* 24-week follow-up, *MoCA* Montreal Cognitive Assessment, *AVLT* Auditory Verbal Learning Test, *STT* Shape Trail Test, *VFT* Verbal Fluency Test *BNT* Boston Naming Test, *DST* Digit Span Test, *LSNS* Lubben Social Network Scale, *BPNS* Basic Psychological Needs Scales, *SAS* Self-Rating Anxiety Scale, *GDS* Geriatric Depression Scale, *MUNSH* Memorial University of Newfoundland Scale of Happiness, *ADL* Activity of Daily Living, *FAQ* Functional Activities Questionnaire, *QoL* Quality of life-Alzheimer's disease. Bold data indicates $P < 0.05$. Time points (T1 and T2 with baseline as reference), and time points and group interaction terms (Group*T1 and Group*T2) are shown for the GEE models

[a] Adjusted with age, sex, education (three levels: elementary school or below, junior high school, and senior high school or above), living status

(two levels: single room or double room), and cluster

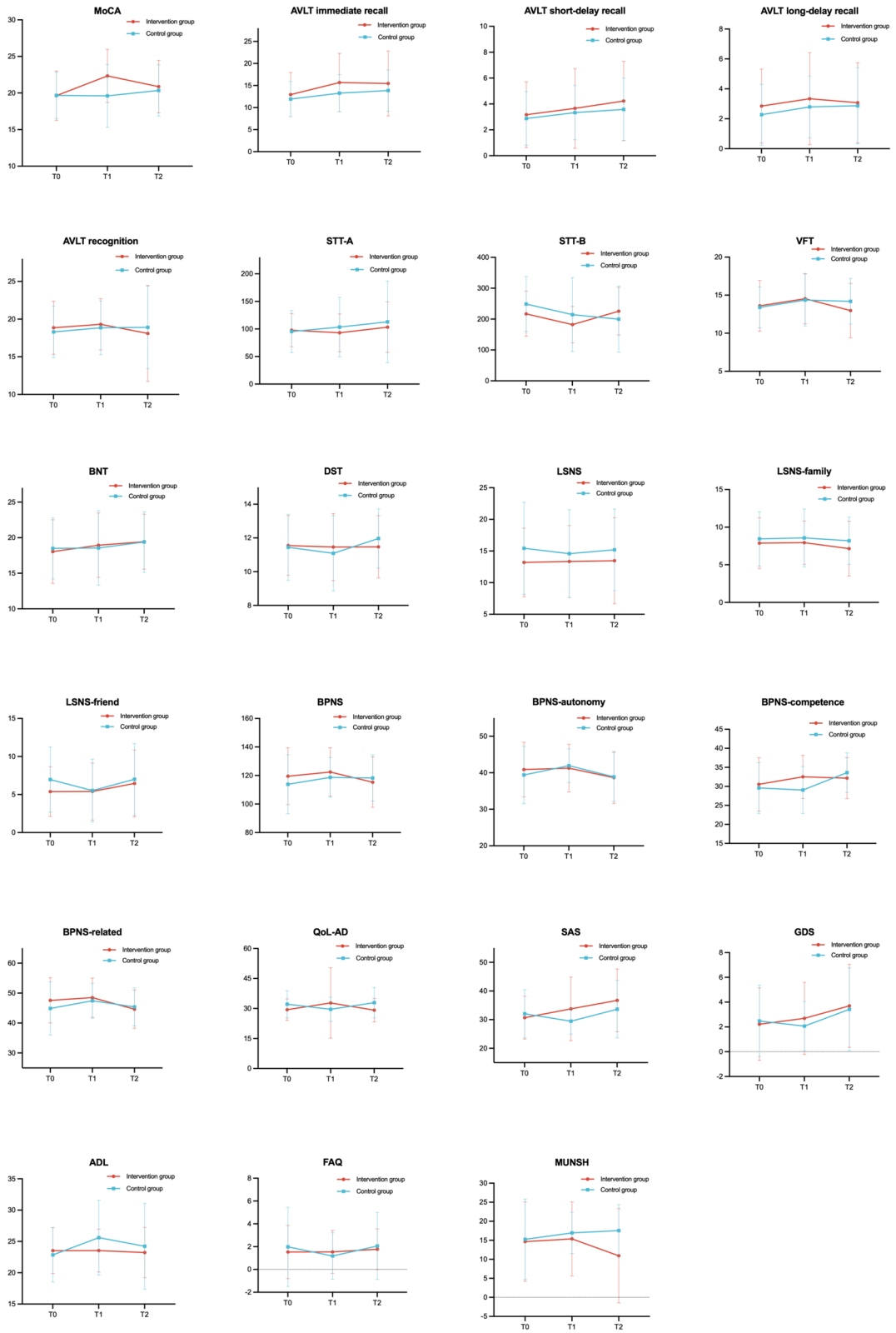

Fig. 3 Indicated the change in primary and secondary outcomes between two groups at different time points

Subtheme 3.2: Limited functional skill transfer.

Although participants enjoyed the activities, these "training games" did not consistently translate into enhanced daily functional skills, which may explain the stagnant outcomes in functional abilities and quality of life.

"These activities feel like 'training games'—not applicable to real life." (P3, 80–84 years old).

"Painting landscapes brought joy, but it doesn't aid in organizing daily routines." (P13, 80–84 years old).

Discussion

Findings

This mixed-methods study explores the short-term cognitive effects and implementation challenges of an integrated social-art intervention for institutionalized older adults with MCI. While intention-to-treat analyses indicated a clinically meaningful improvement in global cognitive function at T1 (MoCA $\Delta = 2.71$, $P < 0.001$), surpassing the minimal clinically important difference (MCID) threshold for MCI [65, 66], this effect diminished by T2 (MoCA $\Delta = 1.32$, $P = 0.448$). Critically, the absence of sustained cognitive benefits—combined with null effects on psychosocial indicators, functional abilities, and quality of life—suggests that short-term cognitive stimulation alone may not yield lasting clinical improvements.

The observed short-term cognitive gains align with prior studies linking social engagement [9] and creative expression [38] to cognitive stimulation in older adults. For example, art-based interventions involving multimodal tasks (e.g., painting, storytelling) may enhance psychological resilience and self-efficacy [67], while group dynamics in structured settings could temporarily mitigate social isolation [9]. However, our study design precludes definitive conclusions about causal mechanisms. The initial improvements may partially reflect practice effects from repeated cognitive testing or transient increases in motivation due to the novelty of structured activities. Critically, the absence of biomarker or neuroimaging data limits our ability to attribute these gains to neurobiological changes.

At follow-up (T2), between-group differences in cognitive function were no longer statistically significant. Qualitative interviews revealed that participants perceived early benefits as contingent on facilitator guidance and structured tasks, but struggled to sustain engagement due to age-related physical limitations (e.g., arthritis, vision impairment) and comorbidities (e.g., hypertension, diabetes). Additionally, while the intervention incorporated strategies to foster peer collaboration (e.g., group art projects), participants reported that social comparisons during sessions occasionally exacerbated anxiety rather than improving well-being. Consistent with previous research findings [68], this phenomenon indicates that the effects of social comparison in group settings are not universally positive and can sometimes increase individual stress and anxiety, thereby partially counteracting the benefits of collaborative activities. These findings highlight the tension between theoretical frameworks emphasizing social connectivity as a protective factor [9] and the lived experiences of frail, institutionalized older adults navigating physical and psychological barriers [69–71].

In contrast to community-based studies reporting broader psychosocial benefits [72–75], our intervention showed no significant effects on functional abilities or quality of life. This discrepancy may stem from the advanced age (mean 86.5 years) and high frailty burden of our cohort [76], which likely constrained their capacity to translate cognitive stimulation into daily functional improvements. Furthermore, institutional barriers—such as rigid care routines, staffing shortages, and COVID-19 restrictions—limited residents' opportunities to apply newly acquired skills outside sessions. For instance, participants noted that pandemic-related visitation policies disrupted familial social connections, a key determinant of well-being in this population [77].

Strengths and limitations of the study

This study contributes to the limited evidence on non-pharmacological interventions for institutionalized older adults with MCI, employing a mixed-methods design to contextualize quantitative outcomes within the nursing home ecology. The integration of SDT principles—such as autonomy-supportive task design—provides actionable insights for tailoring interventions to this population's motivational needs.

However, several limitations must be acknowledged. First, the lack of an active control group prevents disentangling intervention-specific effects from generic social stimulation. Second, repeated MoCA administration may have inflated short-term gains through practice effects, though we attempted to mitigate this by randomizing test order and extending inter-test intervals. Third, the high attrition rate at T2 and limited 24-week observation period restrict conclusions about long-term trajectories. Fourth, while patient-reported scales are validated for cross-sectional use, their sensitivity to detect subtle longitudinal changes in frail older adults remains debated. Fifth, selection bias may have skewed results toward more motivated participants, and the homogeneous urban Chinese sample limits generalizability to other cultural or care settings. Finally, the study's COVID-19

context likely amplified social isolation, underscoring the need for replication in post-pandemic environments.

Conclusions

This study suggests that an integrated social-art intervention may be associated with short-term improvements in cognitive function among institutionalized older adults with MCI, though these potential benefits were not sustained post-intervention. The observed pattern of limited cognitive, functional, and psychosocial gains highlights the challenges of implementing interventions in nursing home environments, where frailty, comorbidities, and institutional barriers may collectively influence outcomes. While the short-term changes observed deserve further investigation, our findings indicate that sustaining improvements likely requires approaches that consider the integration of cognitive stimulation with systemic adaptations (e.g., staff training, flexible scheduling). Future studies would benefit from employing hybrid effectiveness-implementation designs to better understand optimal intervention delivery within routine care frameworks for this vulnerable population.

Abbreviations

AD	Alzheimer's disease
ADL	Activities of Daily Living
AVLT	Auditory Verbal Learning Test
BNT	Boston Naming Test
BPNS	Basic Psychological Needs Scales
CDR	Clinical Dementia Rating
CI	Confidence interval
CONSORT	Consolidation Standards of Reporting Trials
DST	Digit Span Test
FAQ	Functional Activities Questionnaire
GDS	Geriatric Depression Scale
GEE	Generalized Estimating Equations
LSNS	Lubben Social Network Scale
MCI	Mild Cognitive Impairment
MoCA	Montreal Cognitive Assessment
MUNSH	Memorial University of Newfoundland Scale of Happiness
MCID	Minimal Clinically Important Difference
QIC	Independence Model Criterion
QoI-AD	Quality of life-Alzheimer's disease
RCT	Randomized controlled trial
SAS	Self-Assessment Anxiety Scale
SDT	Self-determination theory
SD	Standard deviation
STT	Shape Trail Test
VFT	Verbal Fluency Test

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12916-025-04085-z.

Additional file 1: Figure S1. Artistic works of participants; Table S1. Description of the intervention program according to the TIDieR checklist; Table S2. The 28 sessions of the integrated social-art intervention program; Table S3.The intervention implementation process of the integrated social-art intervention; Table S4. The semi-structured interview guide; Table S5. Demographic characteristics of the interviewers; Table S6. Baseline characteristics and outcome variables of the complete and dropout cases; Table S7. Intra-group comparison of primary and secondary outcomes from intention-to-treat analysis at different time points; Table S8. CONSORT 2010 checklist of information to include when reporting a randomised trial; Table S9. Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist.

Acknowledgements

The authors would like to express their deepest gratitude to all the experts for their invaluable guidance, insightful advice, and unwavering encouragement. We are also profoundly thankful to all the participants, staff, and administrators of the nursing homes for their continuous and steadfast support.

Authors' contributions

CSH: Writing – original draft, Writing – review & editing, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. YJY: Writing – original draft, Writing – review & editing, Project administration, Methodology, Data curation, Funding acquisition, Conceptualization. WWST: Writing – review & editing, Methodology, Formal analysis, Conceptualization. WQS, YY, NFW, YHS, ZPZ, DTC, LC: Project administration, Investigation, Data curation. JYZ: Writing – review & editing. RL: Writing – review & editing, Supervision, Project administration, Conceptualization. HL: Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. All authors read and approved the final manuscript.

Funding

This study was funded by the grant from the National Natural Science Foundation of China (Grant number: 82071222), the Joint Funds for the Innovation of Science and Technology of Fujian Province (Grant number: 2020Y9021), the Fund for Scientific Research of Fujian Medical University (Grant number: 2022QH1320), and the Fujian Province Science and Technology-Economy Integration Service Platform (Grant number: FJKX-2024XRH04). Funding agencies had no role in study design and collection, analysis and interpretation of data, and manuscript writing.

Data availability

The data are not publicly available. The data supporting the conclusions of this project will be made available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The Ethics Committee of the Fujian Provincial Hospital approved the project (Approval no. K2022-05–015). All enrolled participants provided written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]The School of Nursing, Fujian Medical University, No.1 Xuefu North Road, Shangjie Town, Minhou County, Fuzhou, Fujian 350122, China. [2]Fujian Provincial Health Commission, No.61 Guping Street, Gulou District, Fuzhou, Fujian 350003, China. [3]Alice Lee Centre for Nursing Studies, Yong Loo Lin School of Medicine, National University of Singapore, Level 2, Clinical Research Centre, Block MD11, 10 Medical Drive, Singapore 117597, Singapore. [4]Department of Nursing, The First Affiliated Hospital of Fujian Medical University, No. 20 Cha Zhong Road, Taijiang District, Fuzhou, Fujian 350005, China.

Received: 30 July 2024 Accepted: 23 April 2025
Published online: 02 May 2025

References

1. GBD 2019 Dementia Forecasting Collaborators. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. Lancet Public Health. 2022;7(2):e105–25.
2. Huang X, Zhao X, Li B, Cai Y, Zhang S, Wan Q, et al. Comparative efficacy of various exercise interventions on cognitive function in patients with mild cognitive impairment or dementia: a systematic review and network meta-analysis. J Sport Health Sci. 2022;11(2):212–23.
3. Yang QH, Lyu X, Lin QR, Wang ZW, Tang L, Zhao Y, et al. Effects of a multicomponent intervention to slow mild cognitive impairment progression: a randomized controlled trial. Int J Nurs Stud. 2022;125: 104110.
4. Ornish D, Madison C, Kivipelto M. Effects of intensive lifestyle changes on the progression of mild cognitive impairment or early dementia due to Alzheimer's disease: a randomized, controlled clinical trial. Alz Res Ther. 2024;16(1):122.
5. Livingston G, Huntley J, Sommerlad A, Ames D, Ballard C, Banerjee S, et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. Lancet. 2020;396(10248):413–46.
6. Perry BL, McConnell WR, Coleman ME, Roth AR, Peng S, Apostolova LG. Why the cognitive "fountain of youth" may be upstream: pathways to dementia risk and resilience through social connectedness. Alzheimers Dement. 2022;18(5):934–41.
7. Lebrasseur A, Fortin-Bédard N, Lettre J, Raymond E, Bussières EL, Lapierre N, et al. Impact of the COVID-19 pandemic on older adults. JMIR Aging. 2021;4(2):26474.
8. Pomeroy ML, Cudjoe TKM, Cuellar AE, Ihara ES, Ornstein KA, Bollens-Lund E, et al. Association of social isolation with hospitalization and nursing home entry among community-dwelling older adults. JAMA Intern Med. 2023;183(9):955–62.
9. Sommerlad A, Kivimäki M, Larson EB, Röhr S, Shirai K, Singh-Manoux A, et al. Social participation and risk of developing dementia. Nat Aging. 2023;3(5):532–45.
10. Stern Y, Arenaza-Urquijo EM, Bartrés-Faz D, Belleville S, Cantilon M, Chetelat G, et al. Whitepaper: Defining and investigating cognitive reserve, brain reserve, and brain maintenance. Alzheimers Dement J Alzheimers Assoc. 2020;16:1305–11.
11. Lanooij SD, Eisel ULM, Drinkenburg WHIM, van der Zee EA, Kas MJH. Influencing cognitive performance via social interactions: a novel therapeutic approach for brain disorders based on neuroanatomical mapping? Mol Psychiatry. 2023;28:28–33.
12. Scarmeas N, Stern Y. Cognitive reserve and lifestyle. J Clin Exp Neuropsychol. 2003;25:625–33.
13. Bennett DA, Schneider JA, Tang Y, Arnold SE, Wilson RS. The effect of social networks on the relation between Alzheimer's disease pathology and level of cognitive function in old people: a longitudinal cohort study. Lancet Neurol. 2006;5:406–12.
14. Sommerlad A, Sabia S, Singh-Manoux A, Lewis G, Livingston G. Association of social contact with dementia and cognition: 28-year follow-up of the Whitehall II cohort study. PLoS Med. 2019;16: e1002862.
15. Kelly ME, Duff H, Kelly S, McHugh Power JE, Brennan S, Lawlor BA, et al. The impact of social activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: a systematic review. Syst Rev. 2017;6(1):259.
16. Pitkala KH, Routasalo P, Kautiainen H, Sintonen H, Tilvis RS. Effects of socially stimulating group intervention on lonely, older people's cognition: a randomized, controlled trial. Am J Geriatr Psychiatry. 2011;19:654–63.
17. Winningham RG, Pike NL. A cognitive intervention to enhance institutionalized older adults' social support networks and decrease loneliness. Aging Ment Health. 2007;11:716–21.
18. Mikkelsen ASB, Petersen S, Dragsted AC, Kristiansen M. Social interventions targeting social relations among older people at nursing homes: a qualitative synthesized systematic review. Inq J Med Care Organ Provis Financ. 2019;56:46958018823929.
19. Cowl AL, Gaugler JE. Efficacy of creative arts therapy in treatment of Alzheimer's disease and dementia: a systematic literature review. Act Adapt Aging. 2014;38(4):281–330.
20. Kim H-K, Kim K-M, Nomura S. The effect of group art therapy on older Korean adults with neurocognitive disorders. Arts Psychother. 2016;47:48–54.
21. Kim HS, Kang JS. Effect of a group music intervention on cognitive function and mental health outcomes among nursing home residents: a randomized controlled pilot study. Geriatr Nur (Lond). 2021;42(3):650–6.
22. Yd S, Lp W, Lrs Y. Effects of non-pharmacological interventions on loneliness among community-dwelling older adults: a systematic review, network meta-analysis, and meta-regression. Int J Nurs Stud. 2023;144: 104524.
23. Cavallo DN, Tate DF, Ries AV, Brown JD, DeVellis RF, Ammerman AS. A social media–based physical activity intervention: a randomized controlled trial. Am J Prev Med. 2012;43(5):527–32.
24. Hwang TJ, Masterman DL, Ortiz F, Fairbanks LA, Cummings JL. Mild cognitive impairment is associated with characteristic neuropsychiatric symptoms. Alzheimer Assoc Disord. 2004;18(1):17–21.
25. Forstmeier S, Maercker A. Motivational processes in mild cognitive impairment and Alzheimer's disease: results from the Motivational Reserve in Alzheimer's (MoReA) study. BMC Psychiatry. 2015;15:293.
26. Deci EL, Ryan RM. Intrinsic motivation and self-determination in human behaviour. New York (NY): Springer Science & Business Media; 2013.
27. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development and well-being. Am Psychol. 2000;55(1):68–78.
28. Slovinec D, Angelo ME, G PL. The roles of self-efficacy and motivation in the prediction of short-and long-term adherence to exercise among patients with coronary heart disease. Health Psychol. 2014;33(11):1344–53.
29. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013;46(1):81–95.
30. Tashakkori A, Teddlie C. The past and future of mixed methods research: from data triangulation to mixed model designs. In: Tashakkori A, Teddlie C, editors. Handb Mix Methods Soc Behav Res. Thousand Oaks, CA: Sage; 2003. p. 671–701.
31. Denise FP, Cheryl TB. Essentials of nursing research: appraising evidence for nursing practice. 7th ed. Philadelphia: Lippincott Williams & Wilkins Press; 2009.
32. Lincoin YS, Guba EG. Naturalistic inquiry. Beverly Hills, CA: Sage Publications, Inc; 1995.
33. Creswell JW, Clark VLP. Designing and conducting mixed methods research. Thousand Oaks (CA): SAGE Publications, Inc.; 2017.
34. State Administration for Market Regulation. GB/T 37276–2018. Beijing: Standards Press of China; 2019.
35. Petersen RC. Mild cognitive impairment as a diagnostic entity. J Intern Med. 2004;256(3):183–94.
36. Lu J, Li D, Li F, Zhou A, Wang F, Zuo X, et al. Montreal cognitive assessment in detecting cognitive impairment in Chinese elderly individuals: a population-based study. J Geriatr Psychiatry Neurol. 2011;24:184–90.
37. Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. Neurology. 1993;43(11):2412–4.
38. Zhao J, Li H, Lin R, Wei Y, Yang A. Effects of creative expression therapy for older adults with mild cognitive impairment at risk of Alzheimer's disease: a randomized controlled clinical trial. Clin Interv Aging. 2018;13:1313–20.
39. Hemming K, Girling AJ, Sitch AJ, Marsh J, Lilford RJ. Sample size calculations for cluster randomised controlled trials with a fixed number of clusters. BMC Med Res Methodol. 2011;11:102.
40. Killip S, Mahfoud Z, Pearce K. What is an intra cluster correlation coefficient? Crucial concepts for primary care researchers. Ann Fam Med. 2004;2(3):204–8.
41. Holloway I, Galvin K. Qualitative research in nursing and healthcare. Hoboken (NJ): Wiley-Blackwell; 2023.
42. Baker SE, Edwards R. How many qualitative interviews is enough? Southampton (UK): National Centre for Research Methods; 2012.
43. Nasreddine ZS, Phillips NA, Bedirian V. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005;53(4):695–9.

44. Zhao Q, Lv Y, Zhou Y, Hong Z, Guo Q. Short-term delayed recall of auditory verbal learning test is equivalent to long-term delayed recall for identifying amnestic mild cognitive impairment. PLoS ONE. 2012;7(12): e51157.
45. Zhao Q, Guo Q, Li F, Zhou Y, Wang B, Hong Z. The Shape Trail test: application of a new variant of the trail making test. PLoS ONE. 2013;8(2): e57333.
46. Guo Q, Jin L, Hong Z. A specific phenomenon of animal fluency test in Chinese elderly. Chin Ment Heal J. 2007;21(9):622–5.
47. Guo Q, Hong Z, Shi W, Sun Y. Boston naming test in Chinese elderly, patient with mild cognitive impairment and Alzheimer's dementia. Chin Ment Heal. 2006;20:81–4.
48. Tamez E, Myerson J, Morris L, White DA, Baum C, Connor LT. Assessing executive abilities following acute stroke with the trail making test and digit span. Behav Neurol. 2011;24(3):177–85.
49. Gj G, Rr M, Cc E. Within-person variation in security of attachment: A self-determination theory perspective on attachment, need fulfillment, and well-being. J Pers Soc Psychol. 2000;79(3):367–84.
50. Lubben J, Blozik E, Gillmann G, Iliffe S, Renteln Kruse W, Beck JC. Performance of an abbreviated version of the Lubben Social Network Scale among three European community-dwelling alder adult populations. Gerontologist. 2006;46(4):503–13.
51. Tao M, Gao J. The validity and reliability of SAS-CR. Chin J Nerv Ment Dis. 1994;20(5):301–3.
52. Tang D. Application of short form geriatric depression scale (GDS-15) in Chinese elderly. Chin J Clin Psychol. 2013;21(3):402–5.
53. Liu R, Gong Y. A trial of the happiness scale at Memorial University of Newfoundland. Chin J Clin Psychol. 1999;2:44–7.
54. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrument activities of daily living. Gerontologist. 1969;9(3):179–86.
55. Pfeffer RI, Kurosaki TT, CH H Jr, Chance JM, Filos S. Measurement of functional activities in older adults in the community. J Gerontol. 1982;37(3):323–9.
56. Yu H, He R, Ai Y, Liang R, Zhou L. Reliability and validity of the quality of life-Alzheimer disease Chinese version. J Geriatr Psychiatry Neurol. 2013;26(4):230–6.
57. Byrne BM. Structural equation modeling with AMOS: basic concepts, applications, and programming. New York: Routledge; 2010.
58. Hollis S, Campbell F. What is meant by intention to treat analysis? Survey of published randomised controlled trials. BMJ. 1999;319(7211):670–4.
59. Liang K-Y, Zeger SL. Longitudinal data analysis using generalized linear models. Biometrika. 1986;73(1):13–22.
60. Pan W. Akaike's information criterion in generalized estimating equations. Biometrics. 2001;57(1):120–5.
61. Zeger SL, Liang KY, Albert PS. Models for longitudinal data: a generalized estimating equation approach. Biometrics. 1988;44(4):1049–60.
62. Ng VKY, Cribbie RA. Using the gamma generalized linear model for modeling continuous, skewed and heteroscedastic outcomes in psychology. Curr Psychol. 2017;36:225–35.
63. Hsieh H-F, Shannon SE. Three approaches to qualitative content analysis. Qual Health Res. 2005;15(9):1277–88.
64. Guba EG, Lincoln YS. Fourth Generation Evaluation. Newbury Park, CA: Sage; 1989.
65. Stojanovic M, Mikula C, John S, Kiselica A. Clinical importance in Alzheimer's disease: effects of anchor agreement and disease severity. Aging Clin Exp Res. 2024;36:5.
66. Lindvall E, Abzhandadze T, Quinn TJ, Sunnerhagen KS, Lundström E. Is the difference real, is the difference relevant: the minimal detectable and clinically important changes in the Montreal Cognitive Assessment. Cereb Circ - Cogn Behav. 2024;6: 100222.
67. Hattori H, Hattori C, Hokao C, Mizushima K, Mase T. Controlled study on the cognitive and psychological effect of coloring and drawing in mild Alzheimer's disease patients. Geriatr Gerontol Int. 2011;11:431–7.
68. Nehrkorn-Bailey AM, Patrick JH, Marello MM. The impact of negative social exchanges on adult physical and mental health. Innov Aging. 2019;3(Suppl 1):S144.
69. Meredith SJ, Cox NJ, Ibrahim K, Higson J, McNiff J, Mitchell S, et al. Factors that influence older adults' participation in physical activity: a systematic review of qualitative studies. Age Ageing. 2023;52:afad145.
70. Tak EC, Uffelen JG, Paw MJ, Mechelen W, Hopman-Rock M. Adherence to exercise programs and determinants of maintenance in older adults with mild cognitive impairment. J Aging Phys Act. 2012;20(1):32–46.
71. Rochon PA, Kalia S, Higgs P. Gendered ageism: addressing discrimination based on age and sex. Lancet. 2021;398(10301):648–9.
72. Lin R, Luo Y, Yan Y, Huang C, Chen L, Chen M. Effects of an art-based intervention in older adults with mild cognitive impairment: a randomised controlled trial. Age Ageing. 2022;51(7):afac144.
73. Yan Y, Lin R, Zhou Y, Luo Y, Cai Z, Zhu K. Effects of expressive arts therapy in older adults with mild cognitive impairment: a pilot study. Geriatr Nurs. 2021;42(1):129–36.
74. Zhao J, Cai W, Su J, Lin R, Ma M, Li H. The effect of creative expression program in neurocognitive networks performance measured by task and resting-state functional MRI. Int Psychogeriatr. 2023;35(8):411–20.
75. Luo Y, Lin R, Yan Y. Effects of remote expressive arts program in older adults with mild cognitive impairment: a randomized controlled trial. J Alzheimers Dis. 2023;91(2):815–31.
76. Song R, Fan X, Seo J. Physical and cognitive function to explain the quality of life among older adults with cognitive impairment: exploring cognitive function as a mediator. BMC Psychol. 2023;11(1):51.
77. Wu B. Social isolation and loneliness among older adults in the context of COVID-19: a global challenge. Glob Health Res Policy. 2020;5:27.

Publisher's Note