Effects of a Digital Multidomain Cognitive Intervention in Older People at High Risk of Dementia:

A Randomized Clinical Trial

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Abstract

Objective: To evaluate the effects of a 6-month digital multidomain cognitive intervention on cognitive function and psychosocial outcomes in older adults at high risk of dementia.

Methods: A 2-arm, randomized clinical trial was conducted at Fujian Provincial Hospital and 4 community health care centers (April 2024 to December 2024). Participants (N = 166, aged ≥60 years, modified dementia risk score >79) were enrolled and randomized 1:1 to a 6-month digital multidomain cognitive intervention and control group. Primary outcomes included general cognitive function (Montreal Cognitive Assessment [MoCA]) scores; secondary outcomes covered memory (Rey-Osterrieth Complex Figure Test [ROCFT] and Auditory Verbal Learning Test), language (Verbal Fluency Test and Boston Naming Test), executive function and attention (Shape Trails Test), visuospatial skill (ROCFT), mobility (Activity of Daily Living and Berg Balance Scale), psychosocial status (15-item Geriatric Depression Scale, Zung Self-Rating Anxiety Scale, UCLA Loneliness Scale, and Quality of Life-Alzheimer's Disease), and health-promoting behaviors (Health-Promoting Lifestyle Profile II and Self-Rated Abilities for Health Practices). Intention-to-treat analysis with random forest imputation was performed.

Results: A total of 154 participants (92.77%) completed the trial. Compared to the control group, the intervention group demonstrated significant improvements in general cognitive function, visuospatial memory, and loneliness, including MoCA ($t = 2.106$, $P = .037$), ROCFT immediate and long-delay recall ($Z = -2.789$, $P = .05$; $t = 2.797$, $P = .05$), and UCLA Loneliness Scale ($Z = -2.641$, $P = .008$). No statistically significant between-group differences emerged in other indicators.

Conclusion: A 6-month digital multidomain intervention significantly enhanced general cognitive function and visuospatial memory and reduced loneliness in older adults at high risk for dementia. These results highlight the potential of WeChat-based delivery models to provide feasible, acceptable, and widely applicable solutions for dementia risk reduction in aging populations.

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Dementia, a chronic progressive neurodegenerative disorder characterized by acquired cognitive impairment,[1] is one of the leading causes of disability among older adults. With the global aging population, dementia has become a significant public health challenge.[2,3] Cognitive decline is often accompanied by neuropsychiatric symptoms and reduced activities of daily living, severely impacting the quality of life for both patients and their caregivers while imposing a substantial economic burden on families and society.[4,5] Despite extensive research, no pharmacologic treatment has been proven to cure dementia,[6] and the clinical efficacy of existing drug therapies remains uncertain, with ongoing debates about their long-term benefits and risks.[3,7] In contrast, non-pharmacologic interventions, particularly cognitive training, have gained attention due to their low cost, low risk, and ease of use,[8–10] as well as their potential to mitigate or delay the effects of aging and neurodegeneration.[11,12] However, the mechanisms and efficacy of cognitive training remain controversial, and evidence for its direct impact on dementia is limited.[13]

Given the complexity, multifactorial nature, and heterogeneity of dementia etiology, no single-domain intervention has been shown to be effective in reducing dementia risk.[14] Research indicates that multidomain interventions, which simultaneously target multiple risk factors, may represent the optimal preventive strategy[14,15] and could provide long-term benefits for high-risk individuals.[16] Several landmark studies, such as the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER) trial,[17–21] the French Multidomain Alzheimer Preventive Trial (MAPT),[22,23] the Dutch Prevention of Dementia by

Intensive Vascular Care (PreDIVA) trial,[24] and the UK Agewell trial,[25–27] have demonstrated that face-to-face, long-term multidomain interventions can improve or maintain cognitive function in older adults at high risk of dementia. The COVID-19 pandemic has accelerated the adoption of information and communication technologies and health informatics, providing new, user-friendly digital platforms for older adults.[28] With increasing digital connectivity among older populations, web-based multidomain interventions have attracted growing attention, as evidenced by the European Healthy Ageing Through Internet Counselling in the Elderly (HATICE) trial,[29] the French Enhancing Multidomain Interventions for Dementia Prevention (eMIND) trial,[30] and the Australian Body, Brain, Life (BBL) trial series.[31–33] Notably, the Australian BBL trials demonstrated that a 12-week web-based personalized multidomain intervention could reduce dementia risk in high-risk middle-aged adults, with effects sustained for at least 15 months. Importantly, face-to-face components did not enhance intervention efficacy or adherence to the online program. Similarly, a 6-month randomized controlled trial conducted by Yang et al[34] in Guangzhou, China, confirmed that multidomain interventions significantly improved cognitive function, physical function, depressive symptoms, and quality of life in older adults with mild cognitive impairment (MCI) in East Asia. Currently, the ongoing trial of MIND-China[35] aims to delay the onset and progression of dementia and disability in rural populations, but no studies have yet explored long-term digital multidomain interventions in this context.

Early identification of individuals at high risk of developing dementia and who may benefit from targeted risk reduction is a public health priority. Implementing dementia risk reduction at the population level without risk stratification may be impractical and overly resource-demanding.[36] Recent studies, including analyses from the UK Biobank, have emphasized the importance of identifying modifiable risk factors and their joint effects on dementia risk.[37] These findings underscore the need for a multifactorial dementia risk score that incorporates multiple modifiable factors to more accurately identify high-risk individuals and guide tailored interventions.[21,38] Nevertheless, current dementia risk scores are largely based on cardiovascular risk factors and may not adequately capture factors relevant for dementia prevention.[39]

Therefore, this study addresses these limitations by applying a modified dementia risk score (MDRS) that incorporates multimodal risk stratification. We aim to evaluate the effectiveness of a digitally delivered, multidomain cognitive intervention for high-risk older people in community settings, thereby generating insights into dementia risk reduction that may inform future interventions and community-based health service models for older adults.

MATERIALS AND METHODS

Study Design and Setting

This was a 2-arm, parallel, randomized clinical trial conducted at Fujian Provincial Hospital and 4 community health care centers (Fuzhou, Fujian, China). This study included a 6-month intervention (Figure 1). The study was conducted in accordance with the principles of the World Medical Association Declaration of Helsinki, approved by the Ethics Committee of Fujian Provincial Hospital (Approval No. K2024-04-028), and was registered on ClinicalTrials.gov (identifier: NCT06442943). All participants were required by the study investigator to provide informed consent prior to the start of the study. This study followed the Consolidated Standards of Reporting Trials (CONSORT) 2010 reporting guideline (see Supplementary Appendix 1 for details).

Recruitment

Participants were recruited from the hospital and community. Enrollment and randomization occurred from April 2024 to December 2024.

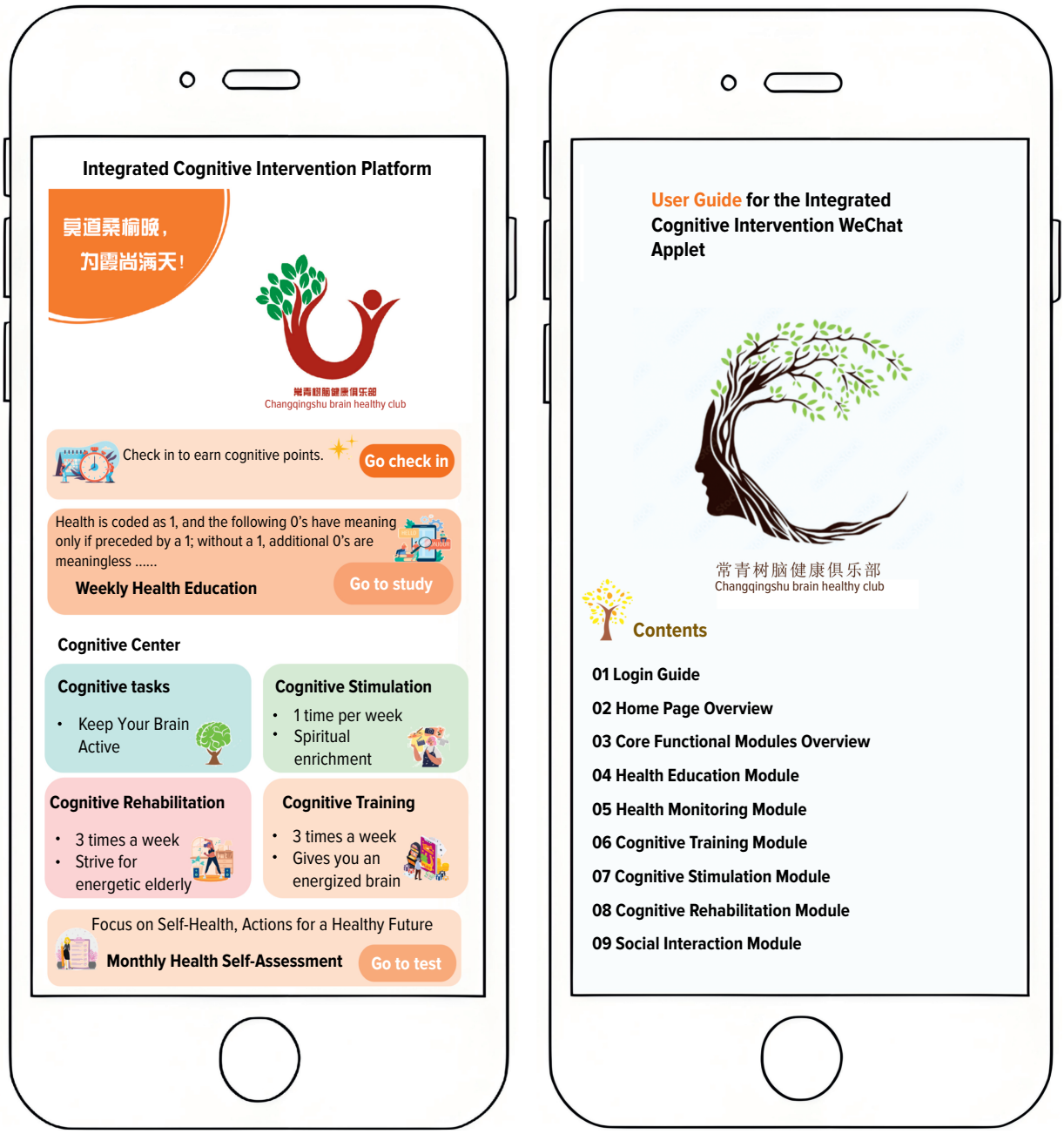
Inclusion and Exclusion Criteria

Inclusion criteria for study participants were (*a*) age ≥60 years; (*b*) high dementia risk, defined by MDRS >79, calculated from multiple risk factors according to the model, excluding apolipoprotein E ε4 (APOE ε4) status (eg, age, gender, education, hypertension, physical activity, and depression), weighted by their association with dementia incidence by UK Biobank cohort[40]—this cutoff represents the top 20% risk percentile (hazard ratio = 3.2, 95% CI: 2.1–4.8), and the detailed scoring algorithm and weight assignments of MDRS are presented in Supplementary Appendix 2; (*c*) ability to communicate normally in Mandarin, with a certain degree of visual and auditory ability to complete the intervention activities; and (*d*) informed about the purpose of the study and agreed to participate. Exclusion criteria were as follows: (*a*) dementia or significant cognitive impairment as determined by a neurologist; (*b*) no smartphone or unable to use the WeChat applet after group and individual instructions; (*c*) accompanied by serious physical disease, physically weak to complete the intervention; (*d*) drug or alcohol dependence; and (*e*) the presence of other neurological diseases that can cause cognitive dysfunction and serious medical diseases.

Sample Size Calculation

The sample size was determined using G*Power 3.1.9.2 (Heinrich Heine Universität Düsseldorf,

Figure 1.
Multidomain Digital Cognitive Intervention Applet



Germany) for a 2-tailed, independent samples *t* test. Based on the effect size (Cohen d = 0.54) derived from prior research,[41] which reported post-intervention Montreal Cognitive Assessment (MoCA) scores of 24.30 (SD = 4.06) in the intervention group and 21.70 (SD = 5.38) in the control group, a minimum of 54 participants per group was required to achieve an α level of 0.05 and a power (1−β) of 0.80. To mitigate a potential 15% attrition rate, the sample size was increased to 64 participants per group (total N = 128). During recruitment, 166 participants were enrolled to ensure robust statistical power, accounting for potential dropouts. This sample size not only exceeds the minimum requirement but also ensures adequate power to detect clinically significant between-group differences.

Randomization and Blinding

Following recruitment, participants were randomized in a 1:1 ratio to the intervention or control group by an independent individual not involved in the trial. The

randomization sequence was generated using the Research Randomizer website (http://www.randomizer.org/) and concealed in sequentially numbered, sealed, and opaque envelopes. Allocation was performed by a staff member who opened these envelopes in numerical order, assigning participants according to the ascending sequence of random numbers, with the first 50% allocated to the intervention group and the remaining 50% to the control group. Given the nature of non-pharmacologic intervention, blinding of the intervention staff and participants was unfeasible. However, the neuropsychological investigator and statistical analyst remained blinded throughout the study, and participants were instructed not to disclose their group allocation during the intervention period.

Interventions

The intervention group implemented a 6-month digital multidomain cognitive intervention, and the control group participated in all data collection activities and was asked to continue their daily activities without the use of the WeChat applet.

This study focuses on the management of brain health in older adults at high risk of dementia. It is informed by the latest international guidance, including *Dementia Prevention, Intervention, and Care: 2020 Report of the Lancet Commission*; the World Health Organization's *Be Healthy, Be Mobile: A Handbook on How to Implement mDementia (mDementia Prevention)*; and the evidence-based Chinese guidelines and expert consensus on dementia prevention, and also builds on previous work conducted by our team.[42–44] Based on these considerations, we developed an integrated intervention platform via a WeChat applet (applet name: Integrated Cognitive Intervention Platform). The Integrated Cognitive Intervention Platform comprises 6 core modules: health education, health monitoring, cognitive training, cognitive stimulation, cognitive rehabilitation, and social interaction (the intervention components, objectives, and rationale of each core module are presented in Table 1 and Figure 1). A point-based incentive mechanism was implemented to enhance participant engagement and adherence.

The intervention components of each core module were implemented as follows. The health education module delivered weekly notifications of dementia-related articles and videos to enhance dementia prevention literacy. The health monitoring module included daily health lifestyle records and monthly self-assessments of emotional state, loneliness, social isolation, and other psychological indicators to promote health awareness and self-management efficiency. The cognitive training module was conducted 3–5 times per week, targeting memory, executive function, visuospatial ability, and attention, with a recommended minimum of 120 minutes weekly to strengthen cognitive reserve. The cognitive stimulation module provided weekly art-based assignments to stimulate creativity and hand-eye-brain coordination. The cognitive rehabilitation module involved aerobic, resistance, and balance exercises, along with traditional mind-body practices such as Tai Chi and Baduanjin, performed 3–5 times per week for at least 120 minutes weekly to maintain activities of daily living, prevent physical frailty, and support both cognitive and noncognitive functioning. Finally, the social interaction module ran throughout the intervention, encouraging social participation through mutual feedback on creative artworks, such as likes and comments, and sharing task participation and progress within the WeChat group. The detailed intervention schedule is available in Supplementary Appendix 3.

The Integrated Cognitive Intervention Platform and its management system have been registered in the China Copyright Protection Center (registration nos. 2024SR1274897 and 2024SR1274898). The platform was designed with age-friendly adaptations, and detailed description of the intervention platform and management system is provided in Supplementary Appendix 4.

Intervention Adherence

Intervention adherence was quantified using objective data extracted from the digital platform's management system. Overall adherence was determined based on cumulative cognitive points, with participants achieving a total score ≥2,562 points (ie, the minimum monthly threshold of 427 points for basic adherence × 6 months) classified as the high-adherence group, and those below this threshold classified as the low-adherence group. To examine participation heterogeneity across intervention modules, adherence to individual components was also assessed: For participation-based modules (ie, daily health lifestyle record, health education, and cognitive stimulation), participants with a completion rate >80% were categorized as the high-engagement group, following previous methodology[65]; for time-based modules (ie, cognitive rehabilitation and cognitive training), participants were grouped according to their average weekly duration (<60 min, 60–120 min, and >120 min) to explore potential differential effects of the intervention based on adherence levels.

A dual monitoring strategy integrating passive system tracking and active researcher follow-up was employed to promote adherence. The digital platform automatically recorded participants' engagement across all modules, including health education viewings, daily lifestyle logs, monthly self-assessments of emotional state and psychosocial well-being, cognitive training completions, art-based assignment submissions, rehabilitation exercise completions, and participation in social interaction activities. Research assistants conducted weekly reviews of these system records during the first 3 months of the

Table 1.
Specific Content and Rationale for Multidomain Digital Cognitive Intervention Program

Module	Intervention content	Intervention objectives
Health Education	Each week, participants were required to study health education materials, including articles or videos on the current epidemiology of dementia, its clinical manifestations and early signs, risk and protective factors, prevention and treatment strategies, and policy safeguards related to dementia prevention. To encourage careful reading, each article or video was accompanied by corresponding questions, and participants received an additional 2 cognitive points for each correct answer.	To improve dementia health literacy, strengthen knowledge and confidence in dementia prevention, and promote healthy lifestyles.
Health Monitoring	Chronic disease prevention and control activities, along with healthy lifestyle behaviors and habits, were required to be documented daily, while health conditions such as anxiety, depression, loneliness, social isolation, and overall well-being were assessed monthly.	To monitor self-health, raise health awareness, and enhance self-care ability.
Cognitive Training	Cognitive domains such as memory, executive function, visuospatial ability, and attention are recommended to be trained 3–5 times/ wk, for at least 120 min per wk, with participants able to select the training difficulty according to their individual level.	To improve cognitive function and increase cognitive reserve.
Cognitive Stimulation	Participants were required to complete 1 art creation per week based on the published activity theme on the WeChat applet. The type of art was not limited and could include, but was not restricted to, visual arts (painting, crafts, collage, etc), performing arts (music, dance, theater, etc), and literary arts (calligraphy, reading, poetry writing, etc), encouraging the integration of multiple art forms in a single creation.	To enhance hand-eye-brain coordination, stimulate imagination and creativity, and promote interpersonal interaction and communication for better cognitive and social functioning.
Cognitive Rehabilitation	Adopting a sports rehabilitation approach and adhering to the training principles of gradual progression, consistency, and individualization, the program incorporates aerobic exercise, resistance training, balance exercises, and traditional practices such as Tai Chi and Baduanjin. A total weekly training duration of no less than 120 min is recommended.	To maintain the ability to perform activities of daily living, prevent physical decline, and improve both cognitive and noncognitive symptoms (eg, psychiatric symptoms).
Social Interactions	Interactive engagement among participants was encouraged through expressing appreciation for others' artwork via likes and comments, as well as sharing their task participation and progress within the WeChat group.	To increase perceptions of social participation, reduce feelings of isolation, and enhance social contact and interaction with others.

References: (1) 2020 Report of the Lancet Commission.[38] (2) Risk Reduction of Cognitive Decline and Dementia.[45] (3) Global Status Report on the Public Health Response to Dementia.[46] (4) Be Healthy, Be Mobile. A Handbook on How to Implement mDementia (mDementia Prevention).[47] (5) Social Isolation And Loneliness Among Older People advocacy brief.[48] (6) Chinese Expert Consensus on Brain Cognitive Health Management (2023).[49] (7) Chinese Expert Consensus on Rehabilitation Management for Alzheimer's Disease (2019).[50] (8) Clinical Practice Guidelines for Non-pharmacological Interventions in Physical Activity for Elders with Cognitive Decline.[51] (9) Active Brain Health to Enhance Cognitive Reserve.[52] (10) Chinese Guidelines for Primary Prevention of Alzheimer's Disease.[53] (11) Risk Factors and Prevention of Alzheimer's Disease.[54] (12) China Alzheimer's Disease Blue Paper (Abbreviated Edition).[55] (13) Chinese Expert Consensus on Rehabilitation for Cognitive Frailty.[56] (14) Chinese Guidelines for Early Prevention Strategies of Alzheimer's Disease.[57] (15) International Evidence-based Guidelines for Prevention of Alzheimer's Disease.[58] (16) China Alzheimer's Disease Report.[59] (17) Scientific Research Report on the Dietary Guidelines for Chinese Residents.[60] (18) Dietary Guidelines for Chinese Elders.[61] (19) Physical Activity Guidelines for Chinese Population.[62] (20) Guidelines for Daily Fitness Exercises for Elders.[63] (21) Expert Consensus on Motor Function Assessment and Intervention for Elders at Home.[64]

intervention to identify participants who had missed certain tasks or to determine the reasons for inactivity lasting more than 1 week. Those participants subsequently received reminder calls or WeChat messages to encourage continued engagement.

Outcome Assessment

To explore the effects of the digital multidomain cognitive intervention on cognitive function and psychosocial outcomes in older adults at risk of dementia, various measurements were obtained at baseline (T0) and after the 6-month intervention immediately (T1). In addition to the primary and secondary outcomes, general information was collected using a baseline questionnaire. This included general sociodemographic information about the study population (age, gender, education, state of residence and marital status, etc) and medical history information (including history of disease, family history of dementia, and history of falls, etc), as well as personal lifestyle habits and social participation (eg, smoking, alcohol consumption, physical activity, leisure intellectual activities, interactions with friends, interactions with children, and participation in organized group activities).

The primary outcome measure was general cognitive function assessed at T0 and T1, as measured using the MoCA.[66]

The secondary outcomes included 13 indicators across 4 domains: specific cognitive function, mobility, psychosocial status, and health-promoting behaviors, assessed at baseline (T0) and post-intervention (T1). Specific cognitive function was evaluated using the Auditory Verbal Learning Test (AVLT),[67] Rey-Osterrieth Complex Figure Test (ROCFT),[68] Verbal Fluency Test (VFT),[69] Boston Naming Test (BNT),[70] and Shape Trails Test (STT),[71] covering memory, language, executive

function, attention, and visuospatial skills. Mobility was assessed through the Activity of Daily Living (ADL) scale[72] for daily functioning and the Berg Balance Scale (BBS)[73] for balance. Psychosocial status was evaluated with the 15-item Geriatric Depression Scale (GDS-15),[74] the Zung Self-Rating Anxiety Scale (SAS),[74] the UCLA Loneliness Scale, and the Quality of Life-Alzheimer's Disease (QoL-AD).[75] Health-promoting behaviors were measured using the Health-Promoting Lifestyle Profile II (HPLP-II)[76] and the Self-Rated Abilities for Health Practices (SRAHP) Scale.[77]

Data Collection

After obtaining informed consent, general sociodemographic information and neuropsychological tests were collected by professionally trained investigators. All data were subsequently summarized, cross-checked, and centrally entered by researchers who were not directly involved in participant contact. Investigators, as well as researchers responsible for data entry and statistical analyses, were blinded to the intervention allocation and subgroup classification.

Statistical Analyses

All statistical analyses were performed using IBM SPSS Statistics (version 29.0) according to the intention-to-treat (ITT) principle. For medium-sized samples ($50 < n < 300$), normality was tested using the absolute z-value of skewness and kurtosis; values exceeding 3.29 (corresponding to $\alpha = .001$) indicated nonnormal distribution. Normally distributed data are presented as mean ± standard deviation (SD) and were compared between groups using independent samples t-tests, with homogeneity of variance verified by Levene test. Nonnormally distributed data are expressed as median (P25, P75) and were compared using the Mann-Whitney *U* test. Categorical variables are described as numbers (percentages) and were analyzed using Pearson χ^2 test (when all expected cell frequencies were ≥5) or Fisher exact test when appropriate. Between-group differences in intervention effects were assessed using change scores (post-intervention minus baseline values), employing parametric or nonparametric tests based on the distribution of the change scores. Missing data were imputed using the random forest algorithm in R (version 4.3.1). Subgroup analyses were conducted to explore potential effect modifications by baseline characteristics, including general demographic characteristics (eg, age, gender, education level, marital status, residence status), lifestyle factors (eg, smoking, alcohol consumption, physical activity, leisure intellectual activities, social participation), medical history conditions (including history of disease, family history of dementia, and history of falls, etc), and MCI subtype. Continuous outcomes were compared between intervention and control groups within each subgroup using independent samples *t* tests or Mann-Whitney *U* tests, as appropriate. Categorical outcomes were compared using χ^2 or Fisher exact tests. Furthermore, to quantify the magnitude of observed differences, effect sizes were calculated and reported: Cohen *d* for *t* tests, rank biserial correlation for Mann-Whitney tests, and Cramér *V* for χ^2 tests. All tests were 2-tailed, with a statistical significance level set at $\alpha = .05$.

RESULTS

Enrollment

A total of 312 patients were initially screened, of whom 138 were excluded for not meeting the inclusion or exclusion criteria. The remaining 166 participants were randomized to either the digital multidomain cognitive intervention or a control group continuing their usual daily activities. During the study, 12 participants were lost to follow-up, resulting in 154 participants (78 in the intervention group and 76 in the control group) completing the post-intervention assessment. All 166 randomized participants were included in the ITT analysis (Figure 2).

Sociodemographic Characteristics

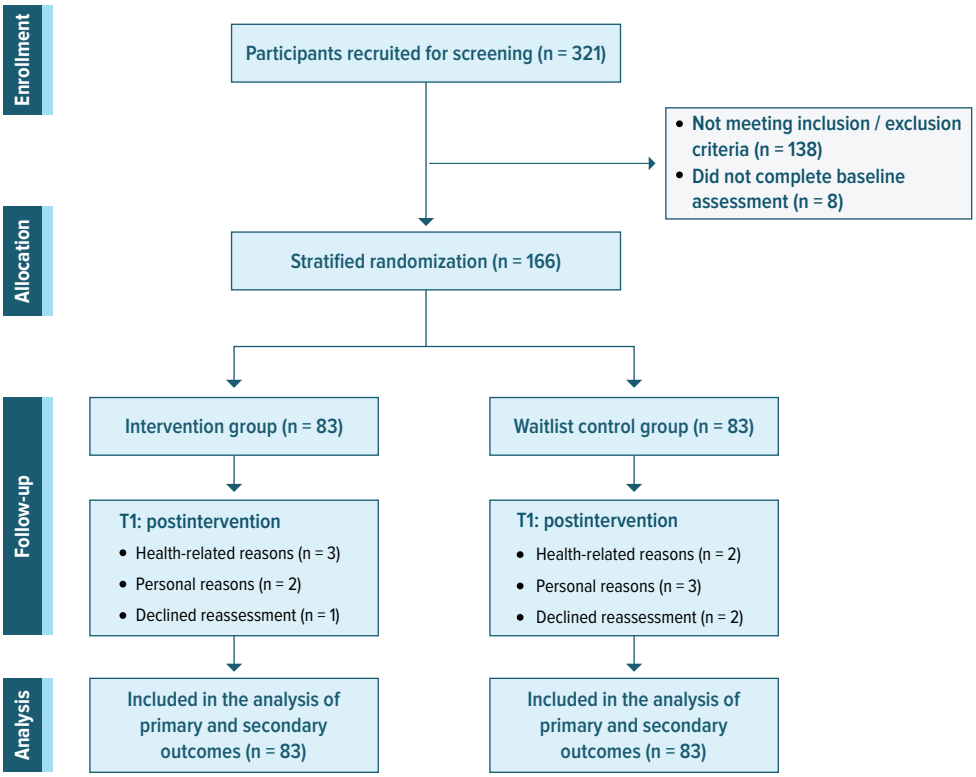
In this study, most participants were female, with the majority having attained at least a secondary level of education. Overall, 28.92% of participants had diabetes mellitus, 51.81% had hypertension, 12.65% reported a family history of dementia, and 18.07% experienced a fall in the past year. Most were nonsmokers (87.35%) and nondrinkers (80.12%), regularly engaged in physical activity, and reported frequent social interactions with their children and friends (79.52% and 81.93%), whereas participation in leisure intellectual activities was relatively low, with 62.05% reporting no or rare engagement.

When examined by group, the intervention group had a mean dementia risk score of 113.07 ± 11.67, a mean age of 74.83 ± 5.44 years, and a mean number of chronic diseases of 1.66 ± 1.24. In the control group, the corresponding values were 114.70 ± 11.57, 74.55 ± 5.62 years, and 1.35 ± 0.97, respectively. No significant differences were observed between the two groups in general sociodemographic information, medical history information, and personal lifestyle habits and social participation ($P > .05$), indicating that the groups were well balanced and comparable (Table 2).

Neuropsychological Outcomes

Following the 6-month intervention, significant between-group differences were observed in general cognitive function and selected cognitive and psychosocial outcomes. Specifically, the intervention group demonstrated greater improvements in MoCA scores ($t = 2.106$, $P = .037$, $d = 0.327$), as well as in visuospatial memory as measured by the ROCFT

Figure 2.
Flowchart of Study Participants



immediate recall ($t = 2.42$, $P = .017$, $d = 0.376$) and long-delayed recall ($t = 2.797$, $P = .006$, $d = 0.434$). Furthermore, participants in the intervention group reported a significant reduction in loneliness, as indicated by the UCLA Loneliness Scale ($Z = -2.641$, $P = .008$, $r = 0.237$).

Other cognitive domains, including verbal function (VFT and BNT), verbal memory (AVLT short-, long-delayed, and recognition recall), attention, and executive function (STT-A/B), as well as physical function (ADL and BBS) and health-promoting behaviors (HPLP-II and SRAHP), showed improvements or maintenance in the intervention group; however, between-group differences did not reach statistical significance ($P > .05$). Similarly, changes in depression and anxiety levels (GDS-15 and SAS) and quality-of-life scores (QoL-AD) were favorable in the intervention group but were not statistically different compared with the control group. The detailed information is presented in Table 3.

Subgroup Analysis of Intervention Efficacy Based on Demographic and Clinical Characteristics

Subgroup analyses revealed differences in intervention efficacy across sociodemographic characteristics, lifestyle and social participation factors, medical conditions, and MCI subtype; details are presented in Supplementary Appendix 5 and Supplementary Tables 1–22.

Significant intervention effects were found among participants with tertiary education, showing improvements in MoCA ($t = 2.884$, $P = .006$), ROCFT long-delayed recall ($t = 2.222$, $P = .030$), BNT ($Z = -1.981$, $P = .048$), and STT-B ($Z = -2.407$, $P = .016$), and significant benefits were observed among participants with primary education, showing improvements in VFT ($t = 2.814$, $P = .008$), QoL-AD ($t = -2.067$, $P = .046$), and SRAHP ($Z = -2.514$, $P = .012$). Enhanced effects were also observed in female participants (MoCA: $t = 2.013$, $P = .046$), male participants (ROCFT long-delayed recall: $t = 3.123$, $P = .003$; UCLA Loneliness Scale: $Z = -2.155$, $P = .031$; SRAHP: $Z = -2.951$, $P = .003$), married individuals (MoCA: $t = 1.986$, $P = .049$; AVLT short-delayed recall: $t = 2.086$, $P = .039$; AVLT long-delayed recall: $t = 2.488$, $P = .014$; ROCFT immediate recall: $t = 2.439$, $P = .016$; ROCFT long-delayed recall: $t = 2.560$, $P = .012$; UCLA Loneliness Scale: $Z = -2.654$, $P = .008$; SRAHP: $Z = -2.338$, $P = .019$), and those not living alone (MoCA: $t = 2.513$, $P = .013$; ROCFT immediate recall: $t = 2.527$, $P = .013$; ROCFT long-delayed recall: $t = 2.802$, $P = .006$; UCLA Loneliness Scale: $Z = -2.663$, $P = .008$; SRAHP: $Z = -2.077$, $P = .038$).

Table 2.

Demographics, Medical History, Lifestyle Habits, and Social Participation of the Study Population

Variables[a]	Total (n = 166)	Intervention group (n = 83)	Control group (n = 83)	Statistics	*P*	*d/r/V*
MDRS score, mean ± SD	113.89 ± 11.62	113.07 ± 11.67	114.70 ± 11.57	−0.901	.369[b]	0.140
Age, mean ± SD, y	74.69 ± 5.52	74.83 ± 5.44	74.55 ± 5.62	0.323	.747[b]	0.050
BMI, mean ± SD	23.22 ± 3.23	23.16 ± 3.23	23.29 ± 3.25	−0.263	.793[b]	0.003
Number of chronic diseases, mean ± SD	1.51 ± 1.12	1.66 ± 1.24	1.35 ± 0.97	1.812	.072[b]	0.281
Gender				1.419	.234[c]	0.092
Male	49 (29.52)	21 (25.30)	28 (33.73)			
Female	117 (70.48)	62 (74.70)	55 (66.27)			
Education level				2.622	.270[c]	0.126
Primary education	38 (22.89)	22 (26.51)	16 (19.28)			
Secondary education	72 (43.37)	31 (37.35)	41 (49.40)			
Tertiary education	56 (33.73)	30 (36.14)	26 (31.33)			
Marital status				1.177	.278[c]	0.084
Married	141 (84.94)	73 (87.95)	68 (81.93)			
Widowed/divorced/unmarried	25 (15.06)	10 (12.05)	15 (18.07)			
Residence status				0.000	1.000[c]	0.000
Living alone	14 (8.43)	7 (8.43)	7 (8.43)			
Not living alone	152 (91.57)	76 (91.57)	76 (91.57)			
Stroke				0.073	.787[c]	0.021
No	151 (90.96)	75 (90.36)	76 (91.57)			
Yes	15 (9.04)	8 (9.64)	7 (8.43)			
Diabetes mellitus				0.117	.732[c]	0.027
No	118 (71.08)	60 (72.29)	58 (69.88)			
Yes	48 (28.92)	23 (27.71)	25 (30.12)			
Hypertension				0.869	.351[c]	0.072
No	80 (48.19)	37 (44.58)	43 (51.81)			
Yes	86 (51.81)	46 (55.42)	40 (48.19)			
Hyperlipidemia				1.394	.238[c]	0.092
No	134 (80.72)	64 (77.11)	70 (84.34)			
Yes	32 (19.28)	19 (22.89)	13 (15.66)			
Chronic heart disease				0.044	.833[c]	0.016
No	139 (83.73)	69 (83.13)	70 (84.34)			
Yes	27 (16.27)	14 (16.87)	13 (15.66)			
Thyroid diseases				1.437	.231[c]	0.093
No	154 (92.77)	79 (95.18)	75 (90.36)			
Yes	12 (7.23)	4 (4.82)	8 (9.64)			
Suffer from insomnia				13.919	<.001[c]	0.290
No	138 (83.13)	60 (72.29)	78 (93.98)			
Yes	28 (16.87)	23 (27.71)	5 (6.02)			
Family history of dementia				2.671	.102[c]	0.127
No	145 (87.35)	76 (91.57)	69 (83.13)			
Yes	21 (12.65)	7 (8.43)	14 (16.87)			
History of falls in the past year				0.000	1.000[c]	0.000
No	136 (81.93)	68 (81.93)	68 (81.93)			
Yes	30 (18.07)	15 (18.07)	15 (18.07)			
Depression				0.000	1.000[c]	0.000
No	128 (77.11)	64 (77.11)	64 (77.11)			
Yes	38 (22.89)	19 (22.89)	19 (22.89)			
MCI subtypes				0.730	.393[c]	0.066
Nonamnestic MCI	140 (84.34)	72 (86.75)	68 (81.93)			
Amnestic MCI	26 (15.66)	11 (13.25)	15 (18.07)			
Smoking				0.055	.815[c]	0.018
Never	145 (87.35)	73 (87.95)	72 (86.75)			
Used to/still	21 (12.65)	10 (12.05)	11 (13.25)			
Alcohol consumption				0.340	.560[c]	0.045
Never	133 (80.12)	65 (78.31)	68 (81.93)			
Used to/still	33 (19.88)	18 (21.69)	15 (18.07)			
Physical activity				0.034	.855[c]	0.014
Never/occasionally	39 (23.49)	20 (24.10)	19 (22.89)			
Often/active participation	127 (76.51)	63 (75.90)	64 (77.11)			

(continued)

Table 2 (continued).

Variables[a]	Total (n = 166)	Intervention group (n = 83)	Control group (n = 83)	Statistics	*P*	*d/r/V*
Leisure intellectual activities				0.026	.873[c]	0.012
Never/occasionally	103 (62.05)	51 (61.45)	52 (62.65)			
Often/active participation	63 (37.95)	32 (38.55)	31 (37.35)			
Organized group activities				1.083	.298[c]	0.081
Never/occasionally	120 (72.29)	57 (68.67)	63 (75.90)			
Often/active participation	46 (27.71)	26 (31.33)	20 (24.10)			
Interactions with children				0.592	.442[c]	0.060
Rarely/occasionally	34 (20.48)	15 (18.07)	19 (22.89)			
Often	132 (79.52)	68 (81.93)	64 (77.11)			
Interactions with friends				0.000	1.000[c]	0.000
Rarely/occasionally	30 (18.07)	15 (18.07)	15 (18.07)			
Often	136 (81.93)	68 (81.93)	68 (81.93)			

[a]Values are expressed as n (%) unless otherwise noted.
[b]Two-sample independent *t* test.
[c]Chi-square test.
Abbreviations: BMI = body mass index, MCI = mild cognitive impairment, MDRS = modified dementia risk score.

Table 3.

Comparison of Pre- and Postintervention Outcome Indicators Between the Two Study Groups

Variable[a]	Intervention group (n=83)	Control group (n=83)	*t/Z*	*P*	*d/r*
MoCA	0.33 ± 2.91	−0.64 ± 2.99	2.106	.037[b]	0.327
AVLT short-delayed recall	0.6 ± 5.25	−0.31 ± 4.65	1.189	.236[b]	0.185
AVLT long-delayed recall	−0.04 ± 2.92	−0.76 ± 2.36	1.756	.081[b]	0.273
AVLT recognition recall	0 (−1, 1)	0 (−1, 2)	−0.015	.988[c]	0.001
ROCFT immediate recall	0.35 ± 8	−2.69 ± 8.16	2.42	.017[b]	0.376
ROCFT long-delayed recall	0.36 ± 7.77	−3.1 ± 8.16	2.797	.006[b]	0.434
ROCFT copy time	4 (−61, 83)	19 (−35, 70)	−0.767	.443[c]	0.069
VFT	0.19 ± 3.8	−0.28 ± 3.54	0.824	.411[b]	0.128
BNT	1 (−2, 3)	0 (−2, 2)	−1.213	.225[c]	0.109
STT-A	0 (−11, 10)	6 (−10, 22)	−1.735	.083[c]	0.156
STT-B	10 (−38, 30)	11 (−20, 48)	−1.302	.193[c]	0.117
ADL	0 (0, 1)	0 (0, 1)	−0.306	.759[c]	0.024
BBS	0 (−2, 0)	0 (−2, 1)	−0.132	.895[c]	0.012
GDS-15	0 (−2, 1)	0 (−1, 1)	−1.409	.159[c]	0.125
SAS	0 (−3.75, 3.75)	1.25 (−5, 7.5)	−1.636	.102[c]	0.147
UCLA Loneliness Scale	−3 (−10, 0)	0 (−6, 6)	−2.641	.008[c]	0.237
QoL-AD	2.12 ± 6.61	2.93 ± 6.53	−0.791	.430[b]	0.123
HPLP-II	14.51 ± 29.43	16.22 ± 30.1	−0.37	.712[b]	0.057
SRAHP	5 (−13, 24)	0 (−19, 12)	−1.930	.054[c]	0.173

[a]Data are expressed as change from baseline to discharge and presented as mean ± SD or median (P_{25}, P_{75}).
[b]Two-sample independent *t* test.
[c]Mann-Whitney *U* test.
Abbreviations: ADL = Activities of Daily Living, AVLT = Auditory Verbal Learning Test, BBS = Berg Balance Scale, BNT = Boston Naming Test, GDS = Geriatric Depression Scale, HPLP-II = Health-Promoting Lifestyle Profile II, QoL-AD = Quality of Life-Alzheimer's Disease, ROCFT = Rey-Osterrieth Complex Figure Test, SAS = Self-Rating Anxiety Scale, SRAHP = Self-Rated Abilities for Health Practices, STT = Shape Trail Test.

Significant benefits were observed among nonsmokers (MoCA: $t = 2.359$, $P = .020$; ROCFT immediate recall: $t = 2.305$, $P = .023$; ROCFT long-delayed recall: $t = 2.394$, $P = .018$; STT-A: $Z = -2.270$, $P = .023$; UCLA Loneliness Scale: $Z = -2.362$, $P = .018$) and nondrinkers (MoCA: $t = 2.444$, $P = .016$; ROCFT immediate recall: $t = 2.312$, $P = .022$; ROCFT long-delayed recall: $t = 2.103$, $P = .037$; STT-A: $Z = -2.202$, $P = .028$; UCLA Loneliness Scale: $Z = -1.984$, $P = .047$). Participants frequently engaging in physical activities demonstrated significant improvements in AVLT long-delayed recall ($t = 2.376$, $P = .019$), ROCFT immediate recall ($t = 2.540$, $P = .012$), ROCFT long-delayed recall ($t = 3.088$, $P = .002$), and UCLA Loneliness Scale ($Z = -2.361$, $P = .018$). Active leisure intellectual activities participation predicted gains in ROCFT

immediate recall ($t = 2.121$, $P = .038$), ROCFT long-delayed recall ($t = 2.613$, $P = .011$), STT-A ($Z = -2.744$, $P = .006$), GDS-15 ($Z = -2.036$, $P = .042$), SAS ($Z = -2.149$, $P = .032$), and UCLA Loneliness Scale ($Z = -3.974$, $P < .001$), while frequent participation in organized group activities was associated with improved MoCA performance ($t = 2.119$, $P = .040$), UCLA Loneliness Scale ($Z = -3.235$, $P = .001$), and SRAHP ($Z = -2.340$, $P = .019$). Participants often interacting with their children demonstrated significant improvements in ROCFT immediate recall ($t = 2.818$, $P = .006$), ROCFT long-delayed recall ($t = 2.371$, $P = .019$), SAS ($Z = -2.076$, $P = .038$), and UCLA Loneliness Scale ($Z = -2.054$, $P = .040$), while frequent interaction with friends was associated with improved MoCA performance ($t = 2.166$, $P = .032$), ROCFT immediate recall ($t = 2.878$, $P = .005$), ROCFT long-delayed recall ($t = 3.036$, $P = .003$), STT-A ($Z = -2.148$, $P = .032$), SAS ($Z = -2.166$, $P = .030$), UCLA Loneliness Scale ($Z = -3.553$, $P < .001$), and SRAHP ($Z = -2.706$, $P = .007$).

Regarding medical conditions, significant intervention effects were observed in participants without a history of stroke (MoCA: $t = 2.358$, $P = .020$; ROCFT immediate recall: $t = 2.130$, $P = .035$; ROCFT long-delayed recall: $t = 2.679$, $P = .008$; UCLA Loneliness Scale: $Z = -2.753$, $P = .006$), without diabetes (ROCFT immediate recall: $t = 2.947$, $P = .004$; ROCFT long-delayed recall: $t = 2.580$, $P = .011$; STT-A: $Z = -2.068$, $P = .039$; GDS-15: $Z = -2.341$, $P = .019$; UCLA Loneliness Scale: $Z = -2.482$, $P = .013$), without hypertension (QoL-AD: $t = 2.251$, $P = .027$), without hyperlipidemia (ROCFT immediate recall: $t = 2.030$, $P = .044$; ROCFT long-delayed recall: $t = 2.502$, $P = .014$; UCLA Loneliness Scale: $Z = -3.032$, $P = .002$), without chronic heart disease (MoCA: $t = 2.528$, $P = .013$; ROCFT immediate recall: $t = 2.896$, $P = .004$; ROCFT long-delayed recall: $t = 3.521$, $P < .001$; UCLA Loneliness Scale: $Z = -2.138$, $P = .033$), without thyroid diseases (ROCFT long-delayed recall: $t = 2.406$, $P = .017$; UCLA Loneliness Scale: $Z = -2.613$, $P = .009$; SRAHP: $Z = -1.965$, $P = .049$), without insomnia (ROCFT immediate recall: $t = 2.064$, $P = .041$; ROCFT long-delayed recall: $t = 2.607$, $P = .010$; UCLA Loneliness Scale: $Z = -2.230$, $P = .026$), and without depression (UCLA Loneliness Scale: $Z = -2.085$, $P = .037$), indicating better performance to the intervention. Additionally, having no family history of dementia was associated with improved ROCFT immediate recall ($t = 2.495$, $P = .014$), ROCFT long-delayed recall ($t = 2.761$, $P = .007$), and UCLA Loneliness Scale ($Z = -2.523$, $P = .012$), while having no fall history in the past year was associated with improved MoCA performance ($t = 2.135$, $P = .035$), ROCFT long-delayed recall ($t = 2.419$, $P = .017$), UCLA Loneliness Scale ($Z = -2.920$, $P = .003$), and SRAHP ($Z = -2.573$, $P = .010$).

Stratification by MCI subtype showed significant intervention effects in the non-amnestic MCI subgroup for MoCA ($t = 2.420$, $P = .017$), AVLT long-delayed recall ($t = 2.120$, $P = .036$), ROCFT immediate recall ($t = 3.138$, $P = .002$), ROCFT long-delayed recall ($t = 3.912$, $P < .001$), STT-A ($Z = -2.029$, $P = .042$), and UCLA Loneliness Scale ($Z = -2.021$, $P = .043$), whereas no significant between-group differences were detected in the amnestic MCI subgroup ($P > .05$).

Subgroup Analysis of Intervention Effects Based on Adherence Levels

In the adherence-based subgroup analysis, the overall level of adherence did not exert a statistically significant influence on any intervention outcomes (all $P > .05$), including general and specific cognitive function, mobility, psychosocial status, and health-promoting behaviors. With respect to adherence to individual intervention components, several significant effects were observed. Participants with high participation in the health lifestyle record subgroup demonstrated greater improvement in AVLT long-delayed recall ($t = -2.277$, $P = .025$, Cohen $d = 0.607$). Participants in the high-participation health education subgroup showed a significantly greater increase in ROCFT copy time ($Z = -2.165$, $P = .030$, Cohen $d = 0.304$) and ADL scores ($Z = -2.219$, $P = .027$, Cohen $d = 0.267$) compared to those in the low-participation subgroup. Similarly, those with high participation in the cognitive stimulation module exhibited a larger increase in ADL scores ($Z = -2.860$, $P = .004$, Cohen $d = 0.319$). Participants in the high-participation cognitive rehabilitation subgroup demonstrated significant improvements in AVLT recognition recall ($H = 8.557$, $P = .014$, $\varepsilon^2 = 0.104$) and STT-A performances ($H = 14.48$, $P < .001$, $\varepsilon^2 = 0.177$). No statistically significant between-group differences were detected across the cognitive training adherence subgroups. Detailed results are presented in Supplementary Appendix 6.

DISCUSSION

This study is the first to systematically evaluate the effects of a 6-month, multidomain digital cognitive intervention among older adults at high risk for dementia in China. Of the 166 participants enrolled, 154 completed the post-intervention assessment, and 69 of 83 participants in the intervention group met the criteria for high adherence, reflecting strong engagement and sustained participation throughout the study. The intervention led to significant improvements in global cognition and visuospatial memory (MoCA and ROCFT immediate and long-delayed recall) and a reduction in loneliness, while other domains such as language, executive function, attention, mobility, psychosocial

well-being, and health-promoting behaviors showed positive but nonsignificant trends. Subgroup analyses suggested that intervention effects differed across participant characteristics, with greater improvements observed in certain cognitive and psychosocial measures among those with higher education, females, married individuals, nonsmokers, nondrinkers, and those more active in physical, intellectual, or social activities. Participants without chronic conditions such as diabetes, heart disease, and depression, and those with non-amnestic MCI, also showed stronger responses on specific outcomes. Furthermore, adherence analyses indicated that higher participation in specific modules—particularly health monitoring, cognitive stimulation, and rehabilitation—was associated with greater cognitive and functional gains. Together, these findings support the feasibility and potential effectiveness of scalable digital interventions for dementia risk reduction among high-risk older adults.

One of the most important findings of this study was that the intervention significantly improved general cognitive function, as measured by the MoCA, and both immediate and delayed visuospatial memory, as assessed by the ROCFT. Memory, defined as the capacity to encode, store, and retrieve information,[78] is often the first cognitive domain to decline in older adults. This decline, typically marked by memory loss, can impair daily activities, social interactions, and overall quality of life.[79] Our results indicated that, in contrast to the control group, participants in the dementia-risk cohort who received a 6-month multidomain digital cognitive intervention showed significant improvements in global cognitive performance, as well as in visuospatial memory scores (both immediate and long-delayed). These findings suggest that the intervention not only enhanced specific cognitive domains but also contributed to the overall maintenance and strengthening of general cognitive function. The observed improvements may be attributed to the integration of visuospatial cognitive training and multisensory stimulation (encompassing visual, auditory, tactile, and somatomotor modalities) within the intervention, which collectively enhanced participants' information processing and neural efficiency. These findings align with the FINGER study,[21] which demonstrated that a 2-year multidomain intervention improved cognition, executive function, and memory. Although some specific cognitive domains showed improvement, the changes did not reach statistical significance, which may be consistent with findings reported by Li et al,[80] highlighting that intervention design, duration, and participants' baseline cognitive status can all significantly influence intervention efficacy.

Besides cognitive function, this study also found that the intervention significantly reduced participants' feelings of loneliness. Loneliness, stemming from inadequate social networks or the absence of desired emotional companionship, can be categorized into social and emotional loneliness based on its underlying causes.[81] According to the World Health Organization, one-quarter of older adults worldwide experience loneliness, which is equally prevalent across low-, middle-, and high-income countries; however, its substantial impact on health and longevity often remains overlooked.[48] Evidence indicates that loneliness accelerates cognitive decline, increases the risk of cardiovascular disease and dementia, and is associated with a 26%–32% higher mortality risk, thereby affecting overall life expectancy.[48,82] In our study, a 6-month intervention significantly alleviated loneliness, likely by promoting engagement in spiritual and cultural activities that foster stronger social connections, consistent with findings by Meng et al.[83] Encouraging improvements were also observed in other psychosocial outcomes—including depression, anxiety, quality of life, and health-promoting behaviors—among participants in the intervention group; however, these changes did not reach statistical significance. The lack of significant between-group differences in anxiety and depression aligns with results reported by Viviani et al[84] but differs from findings by Hausman et al,[85] which may reflect variations in intervention type, intensity, and baseline psychological status. Similarly, no significant improvement in quality of life was detected, consistent with studies such as Srisuwan et al,[86] yet differing from the marked mental health gains reported by Lee et al.[87] These discrepancies may be explained by differences in baseline quality of life and the specific components of each intervention.

Subgroup analyses further revealed the heterogeneity of intervention effects across populations, indicating the importance of tailoring cognitive interventions to individual characteristics. Participants with higher educational attainment demonstrated more pronounced cognitive improvements, consistent with the cognitive reserve hypothesis. Enhanced neuronal connectivity may buffer against cognitive decline and improve responsiveness to intervention.[88] Participants with only primary education showed greater gains in certain measures, such as VFT and SRAHP, whereas those with tertiary education exhibited larger improvements in general cognitive function, ROCFT long-delayed recall, STT-B, and BNT. These findings suggest that educational background may differentially influence the domains of cognitive and psychosocial benefits derived from the intervention. Female participants showed improvements in MoCA, while male participants demonstrated gains in memory, loneliness, and self-reported health, indicating potential sex-specific responsiveness to intervention. In addition, our study results showed that participants who were married, not living alone, or frequently interacting with children or friends showed greater cognitive and psychosocial benefits. These results indicate that

emotional security and social engagement may enhance adherence and indirectly support cognitive health. Empirical evidence suggests that robust social connections mitigate neuropathological burden and preserve brain function during aging,[89] while promoting cognitive reserve and healthful behaviors.[90] Long-term cohort studies further indicate that social engagement in later life is associated with reduced dementia incidence, likely mediated by enhanced cognitive reserve.[91] These findings support integrating family and peer involvement in future interventions to leverage the synergistic effects of social support.

Subgroup analysis showed that lifestyle and activity factors also influenced intervention outcomes. Nonsmokers and nondrinkers, as well as participants regularly engaging in physical exercise, intellectual leisure activities, or organized group activities, showed greater cognitive and psychosocial benefits. This may be because smoking is associated with cerebrovascular disease, hypertension, and oxidative stress, accelerating cognitive decline,[92,93] while alcohol exerts direct and indirect neurotoxic effects, increasing dementia risk.[94,95] In contrast, regular physical exercise, leisure intellectual activities engagement, and participation in organized group activities may synergize with cognitive training by improving cerebrovascular health, enhancing neurogenesis and synaptic plasticity, and providing cognitive stimulation and social support.[96,97] Notably, in our subgroup analyses, participants with a history of past or current smoking did not show significant intervention effects, whereas past or current alcohol consumers demonstrated improvements in ROCFT long-delayed recall, UCLA Loneliness Scale, and SRAHP. These findings suggest that some cognitive and psychosocial benefits may still be achievable among certain lifestyle risk groups. However, given the relatively small sample sizes in these subgroups, these results should be interpreted with caution and require further validation in larger studies.

Health status and comorbidities may emerge as additional moderators of intervention efficacy. Participants without major medical conditions (eg, stroke, diabetes, dyslipidemia, chronic heart disease), without insomnia or depressive symptoms, and without a family history of dementia consistently showed stronger cognitive and psychosocial responses, highlighting the influence of cardiometabolic health, genetic predisposition, and emotional-sleep balance on intervention effectiveness. Notably, even among participants with chronic conditions, the intervention demonstrated beneficial effects on general cognitive function, specific cognitive domains (memory, attention, executive function), psychosocial outcomes (anxiety, depression, quality of life, loneliness), and health-promoting behaviors, indicating that individuals with chronic diseases may still derive meaningful gains. Moreover, stratification by MCI subtype revealed that participants with non-amnestic MCI experienced significant improvements across multiple cognitive domains and reductions in loneliness, whereas those with amnestic MCI showed more limited benefits. This discrepancy likely reflects the greater hippocampal atrophy and neurodegenerative pathology typically present in amnestic MCI, which may constrain compensatory gains from cognitive training.[98] Taken together, these results suggest that maximizing intervention efficacy requires tailoring strategies not only to individual demographic, social, lifestyle, and health factors but also to MCI subtype, highlighting the importance of a personalized approach to cognitive intervention design.

Overall, adherence levels did not significantly influence most cognitive, behavioral, or psychosocial outcomes, indicating that participants benefited from the intervention even with varying adherence—a promising finding for real-world implementation, where maintaining high adherence is often challenging. This finding is consistent with the study by He et al[99] and underscores the advantage of utilizing widely adopted social platforms for health care interventions. As the dominant social communication application in China, WeChat boasts over 1 billion monthly active users spanning diverse age groups.[100] Its user-friendly interface and digital nature—unconstrained by geographical barriers—facilitate large-scale dissemination among older adults, highlighting its substantial potential for health care applications. This study provides initial empirical evidence supporting the development and implementation of digital dementia prevention interventions within the sociocultural context of China, suggesting that such app-based strategies may serve as an effective complement or alternative to conventional face-to-face cognitive training. Of the 166 participants enrolled, 154 completed the post-intervention assessment, and 69 of 83 participants in the intervention group met the criteria for high adherence, reflecting strong engagement and sustained participation throughout the study. This high adherence may be attributed to the user-friendly design and accessibility of the WeChat-based applet, which allowed participants to conveniently engage with the intervention, as well as to the dual monitoring strategies—combining passive monitoring through the management system of the digital platform and active follow-up from the researcher assistants—that promoted sustained engagement, accountability, and timely feedback. These findings demonstrate the feasibility and acceptability of digital, app-based interventions for older adults at high risk of dementia, supporting their scalability and potential integration into public health strategies.

Despite the lack of overall adherence effects, domain-specific dose-response relationships were observed.

Higher adherence to daily health records was associated with improvements in memory (AVLT long-delayed recall), while greater participation in health education and cognitive stimulation modules was linked to larger observed changes in ADL scores, possibly reflecting that participants who perceived greater risk or decline in daily functioning were more motivated to engage actively in these components. Longer engagement in cognitive rehabilitation moderated executive function (STT-A) and recognition memory (AVLT recognition recall), suggesting that specific intervention components drive domain-specific benefits. These results highlight the potential value of adherence-based tailoring to optimize personalized intervention strategies. Although some cognitive and psychosocial outcomes did not reach statistical significance, consistent trends toward improvement across domains imply that the intervention's synergistic mechanisms may produce meaningful long-term effects. Future refinements could include adaptive algorithms to personalize module selection and difficulty, synchronous online group activities to enhance social support, integration of wearable devices for real-time monitoring of physical activity and sleep, and longer intervention periods with periodic assessments to evaluate cumulative and sustained effects.

Collectively, although multidomain interventions have shown considerable potential in preventing dementia onset and cognitive decline, existing studies present mixed evidence regarding their effectiveness. This variability may be influenced by several factors, including intervention intensity, duration, and long-term outcomes; optimal intervention windows throughout the lifespan; the interplay of risk factors and dose-response relationships; target population and risk stratification; precision and individualization; and geographic and cultural variations. Notably, our digital delivery model demonstrated unique implementation advantages—particularly in scalability, real-time personalization, and accessibility—that may address traditional adherence challenges. As emphasized by Röhr et al,[101] international collaboration remains essential to establish evidence-based protocols while allowing necessary local adaptations for global implementation.

CONCLUSION

This study demonstrates that a 6-month multidomain digital cognitive intervention delivered via a WeChat-based applet holds considerable promise for older adults at high risk of dementia. High adherence observed in the study was likely supported by the user-friendly, accessible digital platform combined with dual monitoring strategies, demonstrating the feasibility and acceptability of app-based interventions for older adults. The intervention led to improvements in general cognitive function and memory and reductions in loneliness, with additional trends toward alleviating anxiety and depressive symptoms, enhancing quality of life, and promoting health literacy and self-management behaviors. Subgroup analyses indicated that intervention effects varied according to demographic, social, lifestyle, and health-related factors, as well as MCI subtype, highlighting the importance of personalized strategies to maximize efficacy. Engagement with particular components—such as health self-monitoring, cognitive stimulation, and home-based physical exercise—can drive targeted benefits. Collectively, these findings provide preliminary empirical evidence supporting the effectiveness, scalability, and adaptability of digital multicomponent interventions in dementia prevention, while emphasizing the need for future large-scale, long-term studies to optimize intervention design, tailor approaches to individual needs, and evaluate sustained effects across diverse populations and cultural contexts.

LIMITATIONS

This study has several limitations. First, as a single-center investigation, the regional and cultural specificity of the sample may restrict the generalizability of our findings to other populations. Second, although the 6-month intervention period was sufficient to demonstrate short-term benefits, it may be too brief to adequately evaluate long-term cognitive outcomes or dementia prevention effects. Third, the outcome assessment relied predominantly on neuropsychological measures and did not include neuroimaging or biomarker data, thereby limiting insight into the neural mechanisms underlying the observed effects. Fourth, while the digital nature of the intervention has advantages in terms of scalability, it may lead to variability in effectiveness due to differences in participants' technological adaptability and access to digital devices. Fifth, although the control design was adopted, the absence of an active control group limits causal inference regarding domain-specific intervention effects. Nonetheless, the comparability of baseline physical, cognitive, and social engagement between groups helps mitigate potential confounding. Future studies incorporating active or component-specific control groups are warranted to further validate the specificity and robustness of multidomain digital cognitive interventions. Sixth, participants were not stratified based on specific cognitive impairment subtypes, which may modulate intervention responsiveness. Seventh, although chronic conditions were recorded, detailed data regarding their control status (eg, glycemic and blood pressure control metrics) were not available. Given the recognized impact of vascular

risk control on cognitive outcomes, future studies should incorporate such measures to better clarify intervention effects. Finally, while not all modifiable risk factors (eg, early-life education, history of traumatic brain injury) were assessed, baseline comparability between groups on key variables supports the internal validity of the study. Future trials would benefit from more comprehensive risk profiling to allow finer-grained subgroup analyses.

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The Journal of Clinical Psychiatry

Supplementary Material

Article Title: Effects of a Digital Multi-domain Cognitive Intervention in Older People at High Risk of Dementia: A Randomized Clinical Trial

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LIST OF SUPPLEMENTARY MATERIAL FOR THE ARTICLE

DISCLAIMER

Appendix 1. CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1-2
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	3-5
	2b	Specific objectives or hypotheses	3-5
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	5-13
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	N/A
Participants	4a	Eligibility criteria for participants	6
	4b	Settings and locations where the data were collected	5-6
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	8-9 Appendix 3-4
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	11-12
	6b	Any changes to trial outcomes after the trial commenced, with reasons	11-12
Sample size	7a	How sample size was determined	7
	7b	When applicable, explanation of any interim analyses and stopping guidelines	7
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	7-8
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	7-8
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	7-8
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	8-11
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	7-8

		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	7-11
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	12-13
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	12-13
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	14
	13b	For each group, losses and exclusions after randomisation, together with reasons	14
Recruitment	14a	Dates defining the periods of recruitment and follow-up	14
	14b	Why the trial ended or was stopped	14
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	14-15
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	14-20 Appendix 5-6
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	14-20 Appendix 5-6
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	N/A
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	14-20 Appendix 5-6
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	14-20 Appendix 5-6
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	29-30
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	20-29
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	20-29
Other information			
Registration	23	Registration number and name of trial registry	1
Protocol	24	Where the full trial protocol can be accessed, if available	N/A
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	30-31

Citation: Schulz KF, Altman DG, Moher D, for the CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. BMC Medicine. 2010;8:18.

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up-to-date references relevant to this checklist, see www.consort-statement.org.

Appendix 2. Detailed Scoring Algorithm and Weighting Scheme of the Modified Dementia Risk Score (MDRS)

Detailed Scoring Algorithm and Weighting Scheme of the Modified Dementia Risk Score (MDRS)			
Model 1 AUC=0.812 Sensitivity=0.861 Specificity=0.643 High risk population score>79			**Model 2** AUC=0.848 Sensitivity=0.794 Specificity=0.757 High risk population score>100
Variables		**score1**	**score 2**
Age, years	40-48	0	0
	49-55	26	26
	56-60	55	55
	61-64	76	76
	>64	100	100
Education	High (college or university level or above)	0	0
	Intermediate (secondary specialized or high school)	4	4
	Low (junior high school and below)	6	6
Gender	Female	0	0
	Male	10	10
Physical activity	Active (at least once a week)	0	0
	Inactive (less than once a week)	3	4
Current smoking status	No	0	0
	Yes	6	6
Glycemic status	≤11.1 mmol/L	0	0
	＞11.1 mmol/L	17	16
Depressive symptoms	No	0	0
	Yes	12	12
APOE ε4 status	Non-ε4	\	0
	ε4	\	26

Appendix 3. Details of the Digital Multi-Domain Cognitive Intervention Course Schedule and Cognitive Point-Based Incentive Rules

Details of the Digital Multi-Domain Cognitive Intervention Course Schedule and Cognitive Point-Based Incentive Rules				
Course Modules	**Course Contents**	**Course Frequency**	**Cognitive Point-Based Incentive Rules**	**Please "√" to complete**
Module 1: Health Education Gain knowledge about brain health	Participants were required to study weekly health education materials, such as dementia-related articles and videos	1 time/ week	Completion of health education materials, including viewing articles/videos: +3 cognitive points per session; answering the accompanying questions correctly: +2 cognitive points per session	
Module 2: Health Monitoring (1) daily health lifestyle record (2) self-assessments of psychological well-being	(1) daily health lifestyle record: record the management of chronic conditions such as diabetes and hypertension, sedentary time, sleep patterns, and daily physical activity (excluding cognitive rehabilitation content delivered via the WeChat applet) (2) self-assessments of psychological well-being: completion of psychological well-being self-assessment test	(1) daily health lifestyle record: 1 time/ day (2) self-assessments of psychological well-being: 1 time/ month	(1) daily health lifestyle record: complete a daily health lifestyle record as required: +3 cognitive points/day (2) self-assessments of psychological well-being: complete one questionnaire: +5 cognitive points per submission (Note: All questions must be answered before submission)	
Module 3: Cognitive Training Cognitive domain training	Cognitive training games targeting domains such as memory, attention, executive function, and visuospatial abilities	3-5 times/ week, for at least 120 minutes per week	Complete the exercises following the video instructions on the WeChat applet (weekly training duration is automatically tracked; after each session, record any fatigue or discomfort in the comments section below the video)**:** (1) Up to 30 minutes of training per week: +10 cognitive points (2) >30 minutes, less than 60 minutes: +15	

			cognitive points (3) >60 minutes, less than 90 minutes: +20 cognitive points (4) >90 minutes, less than 120 minutes: +25 cognitive points (5) >120 minutes:+30 cognitive points	
Module 4: Cognitive Stimulation Brainpower through Creativity	Complete one weekly art creation based on the WeChat applet theme, using any form or combination of visual, performing, or literary arts	1 time/ week	Complete the art-based cognitive assignment and upload it to Communication Interactive (+20 cognitive points/time). Choose to make the artwork public or private; either option does not affect point rewards.	
Module 5: Cognitive Rehabilitation Striving to be a Vibrant Elderly Person	Rehabilitation-based exercises: aerobic, resistance, balance, and traditional practices (Tai Chi, Baduanjin).	3-5 times/ week, for at least 120 minutes per week	Complete the exercises following the video instructions on the WeChat applet (weekly training duration is automatically tracked; after each session, record any fatigue or discomfort in the comments section below the video): (1) Up to 30 minutes of training per week: +10 cognitive points (2) >30 minutes, less than 60 minutes: +15 cognitive points (3) >60 minutes, less than 90 minutes: +20 cognitive points (4) >90 minutes, less than 120 minutes: +25 cognitive points (5) >120 minutes:+30 cognitive points	

Module 6: Social interaction Interpersonal interaction and communication	Interactive engagement among participants was encouraged through expressing appreciation for others' artwork via likes and comments, as well as sharing their task participation and progress within the WeChat group.	/	Interacting with others' works: +1 cognitive point/time for liking, +2 cognitive points/time for commenting.	

Appendix 4. Technical Specifications of the Integrated Cognitive Intervention Platform and Management System

Detailed Description of the Integrated Cognitive Intervention Platform and Management System

Supplementary information

Intellectual Property Certification

To protect the intellectual property rights of the developed system, the Integrated Cognitive Intervention Platform (Chinese name: 整合认知干预平台; Registration No. 2024SR1274897) and the Integrated Cognitive Intervention Management System (Chinese name: 整合认知干预管理系统; Registration No. 2024SR1274898) applied in this study have been officially registered and certified by the China Copyright Protection Center (https://register.ccopyright.com.cn/query.html). This certification ensures both the legal compliance and the technical uniqueness of the programs.

I. Cognitive Training Module

All cognitive training modules were designed based on neurocognitive training strategies using a bottom-up approach[1], which emphasizes extensive and systematic practice with lower-level cognitive processes and gradually builds toward higher-level processes. Each module targeted a specific cognitive domain, including memory, executive function, visuospatial ability, and attention. Participants could select training tasks based on their baseline cognitive assessment results as well as their personal preferences, thereby ensuring individualized relevance and engagement. To monitor adherence, weekly training duration was automatically recorded, with a cumulative total of more than 120 minutes per week defined as excellent performance. Participants who reached this threshold were rewarded with 30 “cognitive points,”

which were displayed in the personal center under “My Cognitive Points” with a detailed incentive record. To prevent excessive use, training time beyond 120 minutes per week did not contribute to additional rewards, although participants were free to continue practicing. This reward–restriction mechanism was intended to optimize adherence while minimizing the risk of fatigue or overtraining.

Within each module, tasks were structured to begin at a simple level, allowing participants to engage in repeated practice and gradually progress to more complex challenges; as the complexity increased, improvements in higher-order cognitive processes were also facilitated. Specifically, memory training included Card Memory and Digital Memory tasks; executive function training incorporated Stroop color-word test and Maze navigation tasks; visuospatial training involved Tower-building and Tetris; and attention training was supported by mindfulness-based exercises. To ensure usability and accessibility for older adults, all modules were adapted with aging-friendly modifications, such as enlarged fonts, simplified interfaces, culturally familiar materials, task prompts, motivational feedback, and appropriate adjustments to task difficulty. The operational feasibility and cognitive load of all modules were validated in pilot feasibility study.

（1）Memory training

Memory training in this program includes Card Memory and Digit Memory tasks.

Card Memory

In the Card Memory task, participants are asked to memorize pairs of cards with identical symbols within a predetermined time window ranging from 5 to 60 seconds, depending on task difficulty (e.g., at the entry level, four cards with two matching pairs are presented for 5 seconds). After the memorization period, all cards are turned face down, and participants are required to recall and match the corresponding pairs. During gameplay, two cards are selected consecutively: if the symbols match, the pair remains uncovered; if they do not, both cards are re-covered. The task continues until

all pairs have been successfully matched, at which point the trial ends. This process systematically trains episodic and visual memory by progressively increasing the number of cards and the memorization duration across difficulty levels (Figure 1).

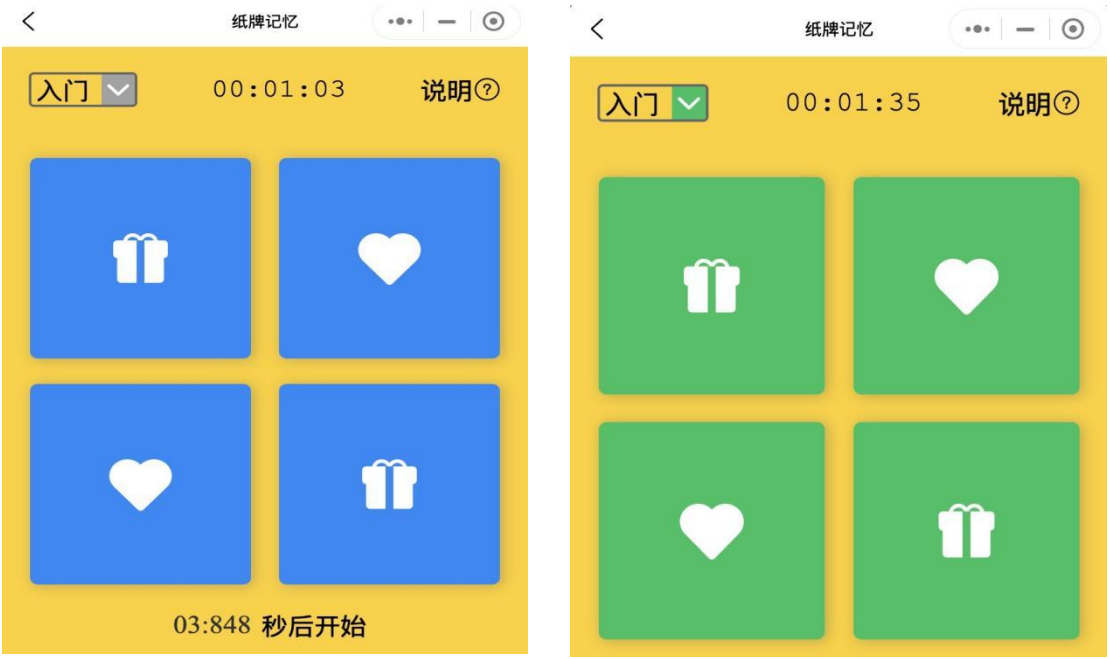

Figure 1. The entry level task of Card memory task

Digit Memory

In the Digit Memory task, participants are presented with a sequence of Arabic numerals for brief exposure. During the recall phase, they are required to select the cards in ascending numerical order. This task is designed to strengthen sequential processing, working memory, and short-term numerical memory. Task difficulty is adjusted by varying the length of the digit sequence and the exposure time, enabling progressive training of memory capacity and information retrieval efficiency (Figure 2).

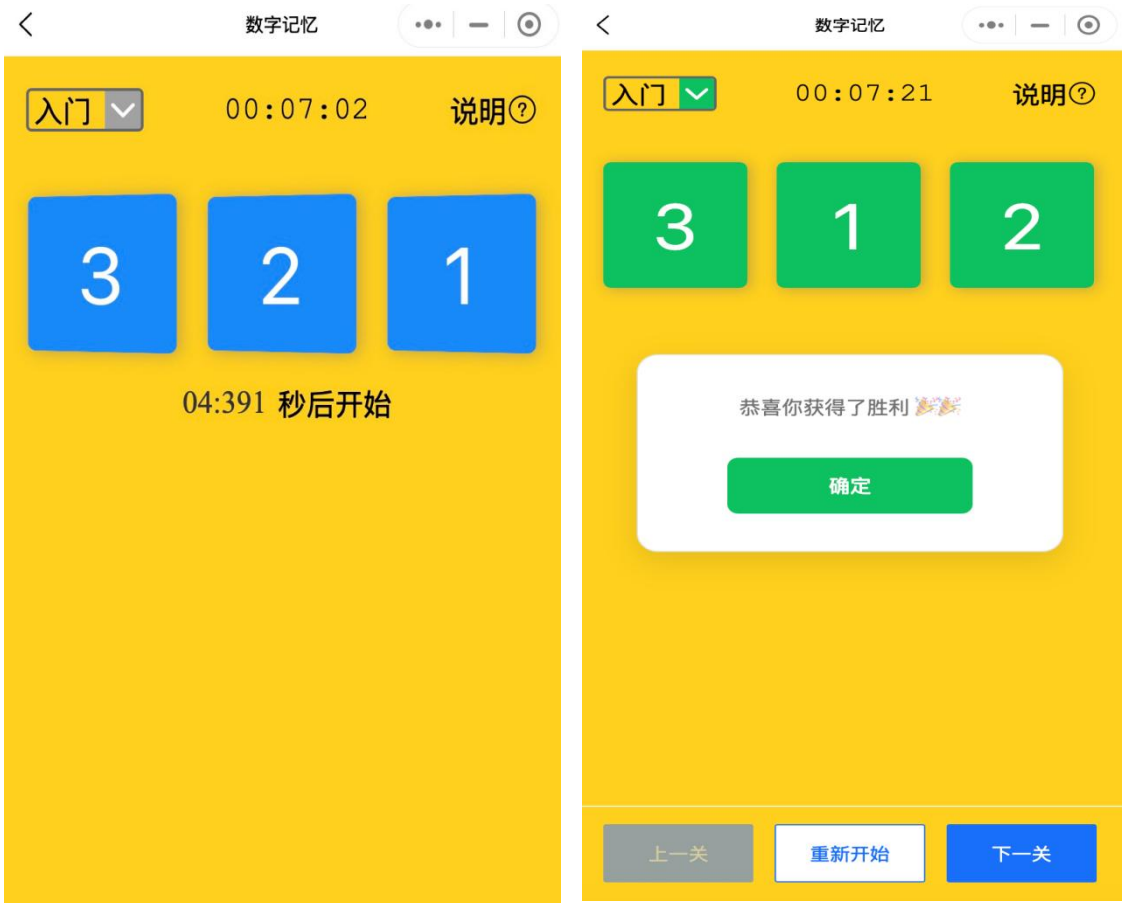

Figure 2. The entry level task of Digit memory task

Executive function training

A set of games focusing on dominant cognitive inhibition, spatial planning, and problem-solving abilities, includes Stroop color-word test and Maze navigation tasks,

Stroop color-word test

This module is adapted from the classic Stroop task and is designed to strengthen executive function by training response inhibition and conflict resolution. Participants are instructed to ignore the semantic meaning of a word and instead identify its font color (e.g., the word “blue” presented in red font should be reported as red). In each trial, a color-related word is displayed (e.g., “Select the color of the word below”), followed by two response options that may be either congruent or incongruent with the stimulus. For example, the word “green” may be shown in blue font, with options such as “green” written in blue and “blue” written in green. Participants are required

to select the option whose word meaning corresponds to the font color of the target word within 60 seconds. Each correct response is awarded 1 point, and consecutive correct answers trigger adaptive difficulty adjustments, such as shortened stimulus presentation time or the addition of distractors (Figure 3).

Figure 3. The details of Stroop color-word test

Maze navigation tasks

This module is designed to strengthen executive function by engaging spatial planning, problem-solving, and cognitive flexibility. Participants are instructed to guide a colored block (initially yellow) from the starting point to the designated exit in the bottom-right corner of the maze. Movement is controlled through on-screen arrow buttons: tapping ↑, ↓, ←, or → shifts the block one step in the corresponding direction, and a "Back" control allows reversal of the previous move. The task begins with simple layouts and progressively increases in complexity. After a

period of practice, participants may select higher difficulty levels, where the maze structures involve longer paths, more dead ends, and greater demands on planning ability. The system provides immediate feedback on both errors and successful moves. Performance is evaluated by completion time and number of errors, with the ultimate goal of reaching the exit as quickly and accurately as possible (Figure 4).

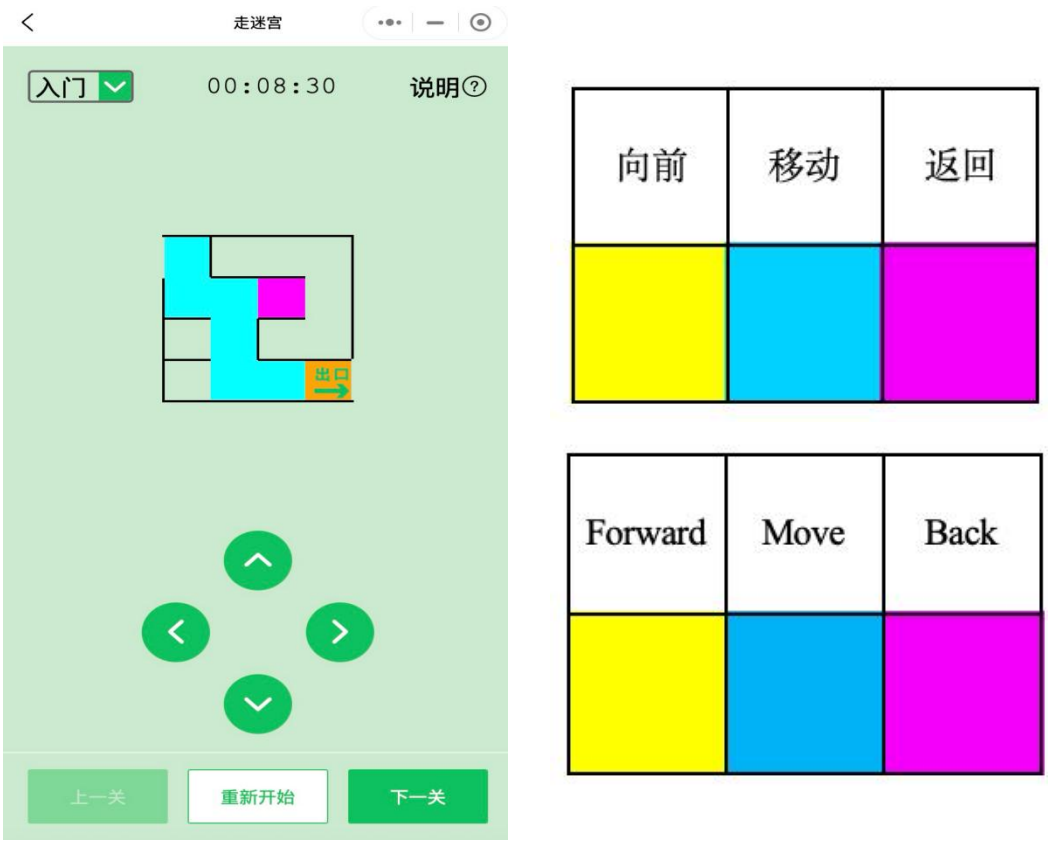

Figure 4. The details of Maze navigation tasks

Visuospatial training

This module focuses on strengthening visuospatial abilities, including spatial relationship judgment, shape manipulation, and three-dimensional structure construction. Two representative tasks are employed: Tower-Building and Tetris tasks.

Tower-building

This visuospatial training module is designed to enhance spatial perception, coordination, and fine motor control. Participants are required to stack moving blocks

on top of each other to build a tower as high as possible. When a moving block overlaps with the one below, the participant taps anywhere on the screen to place it. Only the overlapping portion remains as the new platform, while any non-overlapping part is removed. If a block is placed without any overlap, the game ends. The task begins with slower block movement, allowing easier alignment, and progressively increases in difficulty by accelerating block speed and reducing tolerance for misalignment. This incremental challenge trains visual-motor integration, accuracy of spatial judgment, and sustained attention (Figure 5).

Figure 5. The details of Tower-building tasks

Tetris

This task is adapted from the classic Tetris paradigm and is designed to train visuospatial transformation, mental rotation, and rapid spatial decision-making. Participants are required to manipulate falling geometric blocks in real time, using directional controls to move, rotate, or accelerate the pieces so that they align precisely within a fixed grid. When a full horizontal row is completed, it is cleared

from the screen, allowing continued play. The task begins with slower falling speeds and fewer block variations, gradually increasing in difficulty as speed accelerates and shape complexity grows. The game ends when stacked blocks reach the top of the screen. Performance is evaluated based on the number of rows cleared, accuracy of spatial alignment, and reaction speed, reflecting participants' capacity for dynamic spatial processing and visual–motor coordination.（Figure 6）

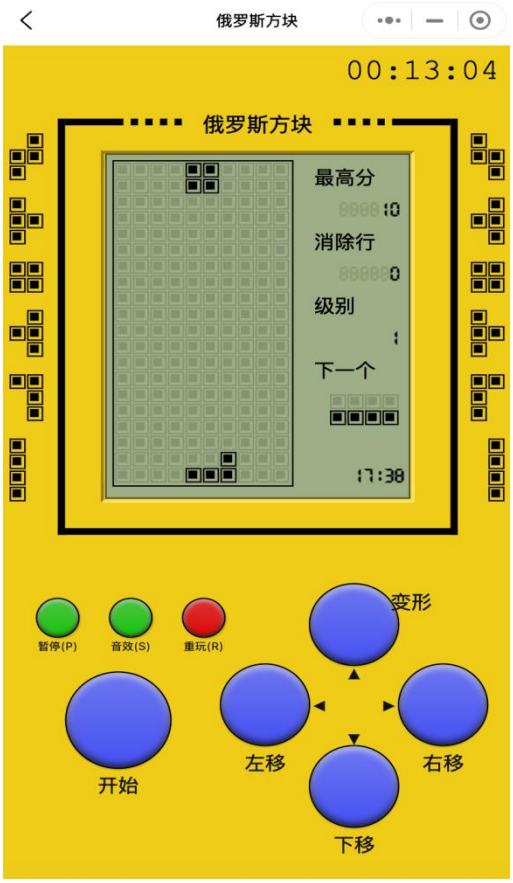

Figure 6. The details of Tetris tasks

Attention Training

This module is designed to strengthen attentional control by targeting sustained focus, resistance to interference, and flexible regulation of attentional scope. The training consists of three core components: Body Scanning, Mindfulness Training, and Relaxation Training.

Body Scanning

Participants are guided to shift their attention sequentially across different body regions, such as from the toes to the head, focusing on physical sensations in each area.

Mindfulness Training

Participants practice maintaining awareness of present experiences, such as breathing or bodily sensations, and gently redirect their focus whenever distraction occurs. Training themes include but are not limited to mindful stress reduction, discovering joy, self-acceptance, and cultivating kindness.

Relaxation Training

Participants engage in guided sessions involving deep breathing, imagery, or progressive muscle relaxation to release tension and establish a calm state that supports attentional engagement.

Each task is delivered through audio-guided sessions with diverse themes, allowing participants to choose according to their preferences (Figure 7).

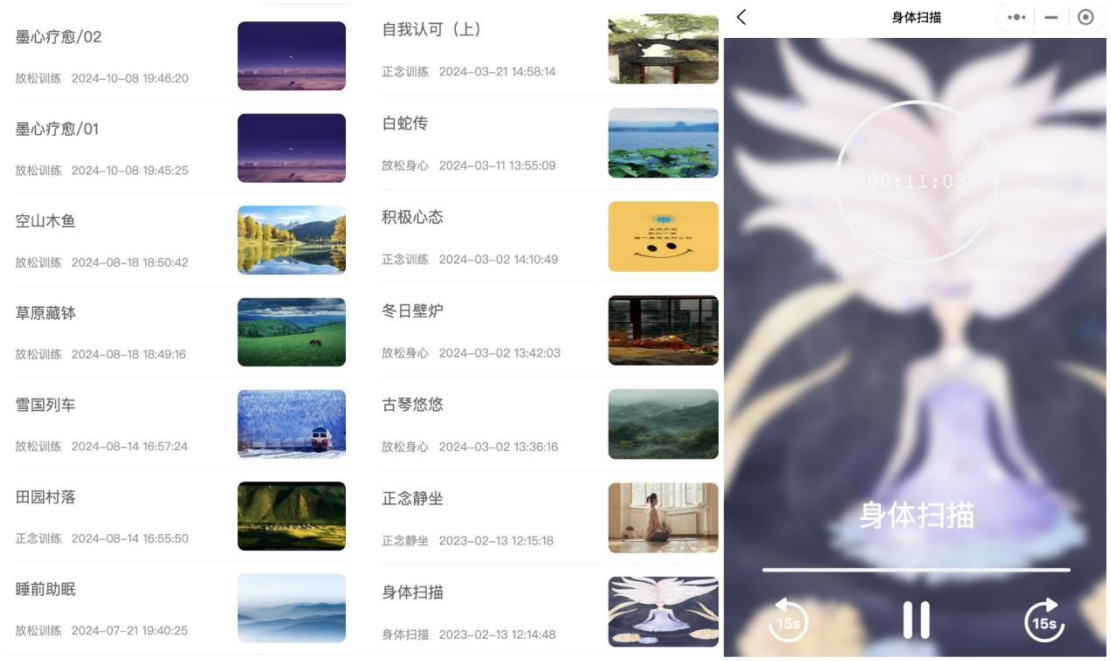

Figure 7. The details of Attention Training tasks

References:

[1] Nuechterlein KH, Ventura J, Subotnik KL, Hayata JN, Medalia A, Bell MD. Developing a Cognitive Training Strategy for First-Episode Schizophrenia: Integrating Bottom-Up and Top-Down Approaches. Am J Psychiatr Rehabil. 2014;17(3):225-253. doi:10.1080/15487768.2014.935674

II. Cognitive Rehabilitation Module

This module adopts structured physical exercise as the core intervention, building on the research evidence from our previous clinical trials [1–3]. It emphasizes the synergistic benefits of multidimensional physical activity and cognitive enhancement. The program consists of several components, including:

(1) Warm-up and Stretching: Gentle movements to prepare the body and reduce injury risk.

(2) Resistance Training: Exercises targeting major muscle groups (e.g., upper limbs, shoulders, back, chest, thighs, and calves). Participants are first guided to learn and practice the correct movement postures, and once proficient, gradually progress to using resistance bands to increase intensity.

(3) Balance Training: Tasks such as side stepping and targeted stepping drills to improve stability.

(4) Flexibility Training: Stretching of the neck, shoulders, and waist to maintain mobility.

(5) Aerobic Exercise: Structured aerobic routines to enhance cardiovascular endurance.

(6) Mind–Body Exercise: Traditional practices including Tai Chi and Baduanjin to integrate body control and relaxation.

(7) Fall Prevention Training: Functional activities to reduce fall risk in daily life.

According to the WHO Guidelines on Physical Activity and Sedentary Behaviour (World Health Organization, 2020), older adults (65 years and above) are recommended to engage in at least 150 minutes of moderate-intensity aerobic

physical activity, or at least 75 minutes of vigorous-intensity activity per week, in addition to muscle-strengthening activities on two or more days. In the intervention group, participants walked for an average of more than three hours per week. Based on this, a cumulative training in the training platform duration of more than 120 minutes per week was defined as excellent performance. Weekly training duration was automatically recorded by the system, and participants reaching this threshold were rewarded with 30 cognitive points which were displayed in their personal center under My Cognitive Points with detailed incentive records. On completion of each session, participants are prompted to report their fatigue level and any discomfort experienced, intervention staff could review participants' exercise duration and self-reported fatigue levels through the backend system, enabling personalized guidance and ensuring exercise safety (Figure 8).

Figure 8. The details of Cognitive Rehabilitation Module

References

[1] Yan, Y., Xu, Y., Wang, X., Wang, Y., Huang, C., Lin, R., Chen, M., Lin, M., & Li, H. (2024). The effect of multi-component exercise intervention in older people with

Parkinson's disease and mild cognitive impairment: A randomized controlled study. Geriatric Nursing, 60, 137–145. https://doi.org/10.1016/j.gerinurse.2024.08.028

[2] Li, N., Wang, N., Xu, Y., Lin, S., Yuan, Y., Huang, F., & Zhu, P. (2025). The impacts of a mHealth platform-enabled lifestyle-integrated multicomponent exercise program on reversing pre-frailty in community-dwelling older adults: A randomized controlled trial. International Journal of Nursing Studies, 167, 105072. https://doi.org/10.1016/j.ijnurstu.2025.105072

[3] Wu, T.-T., Wang, X.-X., Xu, Y.-F., Zhang, C.-F., Huang, M.-Z., & Li, H. (2025). The effect of resistance training for older adults with cognitive frailty: A randomized controlled trial. BMC Geriatrics. (In press).

Ⅲ. Cognitive Stimulation Module

This module consists of two components—art classes and social interaction—designed to enhance hand–eye–brain coordination, stimulate imagination and creativity, promote interpersonal communication, and ultimately improve participants' cognitive and social functioning.

Art Classes

This module was developed based on the nurse-led staged integral art-based cognitive intervention program previously designed by the research team to address cognitive and psychological issues in older adults on the Alzheimer's disease spectrum [1]. The original program incorporated various art activities, including visual arts (e.g., painting, handicrafts, collage), performing arts (e.g., music, dance, drama), and literary arts (e.g., calligraphy, reading, poetry composition). In the current module, weekly art assignments are delivered via an H5 webpage integrating text, images, and video. Each week, participants are introduced to an art theme, engage in warm-up activities, and complete a creative task at home (e.g., producing an artwork). Assignments must be completed and uploaded to the platform within one week, in the form of images or videos. In addition, participants are required to provide a short 、 description, which could be their creative inspiration, process, and experience.

Successful submission earns 20 cognitive points. To protect participants' privacy and intellectual property, they may choose whether to make their work public. In cases of illness, travel, or other valid reasons for absence, participants may contact intervention staff to reopen the submission window and resubmit their assignment.

Social Interaction

After successfully uploading their work, participants may access the social interaction module to view their own or other participants' public submissions. To encourage social engagement, participants are rewarded with +2 cognitive points for providing a comment on another participant's work and +1 cognitive point for giving a "like". These incentives are intended to foster active appreciation, peer feedback, and interactive participation (Figure 9).

Figure 9. The details of Cognitive stimulation Module

References:

[1] Yan, Y., Huang, C., Lin, R., Chen, M., Wang, Y., Xu, Y., Chao, Y., Zhang, C., Sun,

W., Wang, N., Ye, Y., Lin, M., & Li, H. (2024). Effects of a nurse-led staged integral art-based cognitive intervention for older adults on the Alzheimer's disease spectrum: A randomized controlled trial. International journal of nursing studies, 160, 104902. https://doi.org/10.1016/j.ijnurstu.2024.104902

Appendix 5 . Subgroup Analysis of Intervention Efficacy Based on Demographic and Clinical Characteristics

I. General social-demographic characteristics

Table 1. Between-Group Comparisons of Outcome Changes by Educational Level Subgroup

Variables	Primary education				Secondary education				Tertiary education			
	Intervention group (n=22)	Control group (n=16)	*t/Z*	*P*	Intervention group (n=31)	Control group (n=41)	*t/Z*	*P*	Intervention group (n=30)	Control group (n=26)	*t/Z*	*P*
MoCA	0.5 ± 3.02	-0.44 ± 3.14	0.929	0.359[a]	0.26 ± 2.78	0.12 ± 2.89	0.201	0.841[a]	0.27 ± 3.05	-1.96 ± 2.68	2.884	0.006[a]
AVLT-short delayed recall	0.91 ± 4.99	1.75 ± 4.19	-0.547	0.587[a]	1.06 ± 5.66	-0.22 ± 4.43	1.080	0.284[a]	-0.1 ± 5.09	-1.73 ± 4.92	1.214	0.230[a]
AVLT-long delayed recall	-0.36 ± 3.09	-0.31 ± 1.89	-0.059	0.954[a]	0.1 ± 2.71	-0.73 ± 2.5	1.342	0.184[a]	0.07 ± 3.07	-1.08 ± 2.42	1.531	0.132[a]
AVLT-recognition recall	-0.5 (-2.25, 2)	0 (-1, 1)	-0.928	0.353[b]	0 (-2, 1)	0 (-2, 2)	-0.540	0.589[b]	1 (-1, 1.25)	0 (-1.25, 1)	-1.383	0.167[b]
ROCFT-immediate recall	2.14 ± 7.11	0.25 ± 7.28	0.799	0.429[a]	-0.29 ± 7.63	-3.49 ± 9.14	1.576	0.119[a]	-0.3 ± 8.99	-3.23 ± 6.8	1.358	0.180[a]
ROCFT-long delayed recall	1.86 ± 7.38	-0.25 ± 5.4	0.971	0.338[a]	-0.45 ± 7.58	-3.29 ± 9.44	1.374	0.174[a]	0.1 ± 8.32	-4.54 ± 7.13	2.222	0.030[a]
ROCFT-copy time	15.5 (-46, 123.25)	-20.5 (-83.5, 47.25)	-1.405	0.160[b]	9 (-32, 44)	23 (-5, 70)	-1.439	0.150[b]	-36 (-93.25, 71.25)	10.5 (-98.75, 83.75)	-0.756	0.450[b]
VFT	2.09 ± 3.34	-1.13 ± 3.67	2.814	0.008[a]	-0.16 ± 2.9	0.27 ± 3.11	-0.598	0.552[a]	-0.83 ± 4.49	-0.62 ± 4.07	-0.189	0.851[a]
BNT	-0.5 (-3, 3.25)	0 (-1, 3)	-0.743	0.458[b]	1 (-2, 3)	0 (-2, 2)	-0.543	0.587[b]	1 (-1.5, 3)	-2 (-3, 1.25)	-1.981	0.048[b]
STT-A	-1.5 (-13.25, 15.25)	-1.5 (-10.75, 5.75)	-0.340	0.734[b]	0 (-10, 11)	7 (-9, 22)	-1.536	0.124[b]	0.5 (-12.75, 8.5)	9 (-8.5, 28.75)	-1.570	0.116[b]
STT-B	12.5 (-19.25, 24.75)	9.5 (-12.25, 29)	-0.192	0.848[b]	10 (-11, 35)	19 (-37.5, 49.5)	-0.011	0.991[b]	-34.5 (-57.75, 38)	7 (-19.25, 50.5)	-2.407	0.016[b]
GDS-15	-1 (-2.25, 1.25)	0 (-1, 1)	-0.854	0.393[b]	0 (-1, 1)	0 (-1.5, 1)	-0.040	0.968[b]	-1 (-3.25, 1)	0.5 (-1.25, 2)	-1.741	0.082[b]
SAS	-1.25 (-6.56, 4.06)	2.5 (-1.25, 8.44)	-1.510	0.131[b]	1.25 (-2.5, 3.75)	1.25 (-5.82, 7.5)	-0.416	0.677[b]	-1.25 (-6.56, 2.81)	0 (-5, 5.31)	-1.029	0.304[b]
UCLA loneliness scale	-6 (-15.25, 3)	2 (-11.5, 6)	-1.051	0.293[b]	-1 (-8, 0)	0 (-5.5, 5.5)	-1.639	0.101[b]	-4 (-10.75, 2.25)	0 (-6.25, 7)	-1.628	0.103[b]
QoL-AD	0.27 ± 5.28	4.06 ± 5.98	-2.067	0.046[a]	4.35 ± 6.51	2.54 ± 6.66	1.159	0.251[a]	1.17 ± 7.13	2.85 ± 6.82	-0.897	0.374[a]
ADL	0 (0, 1.25)	0 (0, 1)	-0.738	0.460[b]	0 (0, 1)	0 (0, 1)	-0.203	0.839[b]	0 (0, 1)	0 (0, 1)	-0.266	0.790[b]
BBS	0 (-2, 0)	-1 (-2, 0)	-0.686	0.493[b]	0 (0, 1)	0 (-2, 1.5)	-1.105	0.269[b]	-1 (-3, 0)	0 (-2, 1)	-1.299	0.194[b]
HPLP-II	5.95 ± 32.64	12 ± 27.95	-0.598	0.554[a]	16.68 ± 32.27	15.95 ± 30.01	0.098	0.922[a]	18.53 ± 22.85	19.23 ± 32.26	-0.094	0.925[a]
SARHP	13.5 (2.75, 29.5)	-3 (-22.5, 9.5)	-2.514	0.012[b]	2 (-17, 21)	1 (-13, 27.5)	-0.722	0.470[b]	2.5 (-15.75, 18.25)	-2 (-32, 5.25)	-1.947	0.051[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 2. Between-Group Comparisons of Outcome Changes by Gender Subgroup

Variables	Male				Female			
	Intervention group (n=21)	Control group (n=28)	*t/Z*	*P*	Intervention group (n=62)	Control group (n=55)	*t/Z*	*P*
MoCA	-0.05 ± 2.92	-0.61 ± 2.97	0.657	0.515[a]	0.45 ± 2.92	-0.65 ± 3.02	2.013	0.046[a]
AVLT-short delayed recall	1.19 ± 3.92	-0.68 ± 4.25	1.574	0.122[a]	0.4 ± 5.65	-0.13 ± 4.87	0.541	0.590[a]
AVLT-long delayed recall	0.1 ± 2.49	-0.54 ± 2.27	0.924	0.360[a]	-0.08 ± 3.07	-0.87 ± 2.41	1.538	0.127[a]
AVLT-recognition recall	1 (-2, 2.5)	0.5 (-1, 2)	-0.193	0.847[b]	0 (-1, 1)	0 (-1, 1)	-0.374	0.708[b]
ROCFT-immediate recall	-1.81 ± 6.97	-4.61 ± 7.58	1.323	0.192[a]	1.08 ± 8.24	-1.71 ± 8.34	1.817	0.072[a]
ROCFT-long delayed recall	2.19 ± 7.9	-4.43 ± 6.9	3.123	0.003[a]	-0.26 ± 7.69	-2.42 ± 8.71	1.425	0.157[a]
ROCFT-copy time	0 (-58.5, 62)	36 (-2.5, 70.75)	-1.647	0.100[b]	9.5 (-80.25, 90.5)	7 (-42, 65)	-0.205	0.838[b]
VFT	-1.76 ± 4.85	-0.07 ± 2.81	-1.535	0.131[a]	0.85 ± 3.16	-0.38 ± 3.88	1.899	0.060[a]
BNT	0 (-3, 1)	-0.5 (-3, 3)	-0.650	0.516[b]	2 (-2, 3.25)	0 (-2, 2)	-1.710	0.087[b]
STT-A	8 (-3.5, 16.5)	10.5 (-10.25, 22)	-0.202	0.840[b]	-2 (-11.25, 7.25)	5 (-10, 20)	-1.816	0.069[b]
STT-B	3 (-43, 45)	9 (-14.5, 55.5)	-0.606	0.544[b]	10 (-38.25, 28.5)	11 (-21, 45)	-1.049	0.294[b]
GDS-15	0 (-1.5, 2)	1 (-1, 2)	-0.820	0.412[b]	-1 (-2, 0.25)	0 (-2, 1)	-0.828	0.408[b]
SAS	0 (-3.75, 5)	3.75 (-3.44, 7.5)	-0.992	0.321[b]	-0.88 (-5, 2.81)	1.25 (-5, 7.5)	-1.129	0.259[b]
UCLA loneliness scale	-8 (-17, 1.5)	0.5 (-5.25, 6.75)	-2.155	0.031[b]	-1.5 (-8.25, 0.5)	0 (-7, 6)	-1.685	0.092[b]
QoL-AD	1.1 ± 7.09	1.04 ± 6.52	0.030	0.976[a]	2.47 ± 6.47	3.89 ± 6.38	-1.195	0.234[a]
ADL	0 (0, 0)	0 (0, 1)	-1.009	0.313[b]	0 (0, 1)	0 (0, 1)	-0.891	0.373[b]
BBS	0 (-2, 0)	0 (-2, 0)	-0.352	0.725[b]	0 (-2, 0)	0 (-2, 1)	-0.319	0.750[b]
HPLP-II	15.1 ± 22.64	13.68 ± 31.81	0.174	0.863[a]	14.31 ± 31.55	17.51 ± 29.4	-0.566	0.573[a]
SARHP	16 (-1, 27)	-0.5 (-27.25, 3)	-2.951	0.003[b]	4 (-16.25, 21)	0 (-18, 23)	-0.508	0.611[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 3. Between-Group Comparisons of Outcome Changes by Marital Status Subgroup

Variables	Married				Widowed/Divorced/Unmarried			
	Intervention group (n=73)	Control group (n=68)	*t/Z*	*P*	Intervention group (n=10)	Control group (n=15)	*t/Z*	*P*
MoCA	0.19 ± 2.85	-0.81 ± 3.14	1.986	0.049[a]	1.3 ± 3.34	0.13 ± 2.1	1.077	0.292[a]
AVLT-short delayed recall	0.88 ± 5.17	-0.78 ± 4.17	2.086	0.039[a]	-1.4 ± 5.72	1.8 ± 6.14	-1.311	0.203[a]
AVLT-long delayed recall	0.12 ± 2.77	-0.97 ± 2.42	2.488	0.014[a]	-1.2 ± 3.82	0.2 ± 1.78	-1.240	0.228[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 2)	-0.046	0.963[b]	-0.5 (-2, 1.25)	0 (-1, 1)	-0.423	0.672[b]
ROCFT-immediate recall	0.38 ± 7.89	-3.01 ± 8.65	2.439	0.016[a]	0.1 ± 9.18	-1.2 ± 5.43	0.446	0.660[a]
ROCFT-long delayed recall	0.01 ± 7.73	-3.5 ± 8.57	2.560	0.012[a]	2.9 ± 7.98	-1.27 ± 5.82	1.512	0.144[a]
ROCFT-copy time	1 (-63.5, 84)	20 (-20.5, 70)	-0.959	0.337[b]	16 (-66, 54)	-3 (-88, 69)	-0.277	0.782[b]
VFT	0.36 ± 3.95	-0.32 ± 3.62	1.062	0.290[a]	-1 ± 2.21	-0.07 ± 3.26	-0.789	0.438[a]
BNT	1 (-2, 3)	0 (-2, 2)	-0.535	0.593[b]	2.5 (-0.5, 4.25)	-1 (-3, 1)	-1.840	0.066[b]
STT-A	0 (-10.5, 11)	6.5 (-9.5, 21.5)	-1.504	0.132[b]	-1 (-14, 4)	2 (-11, 22)	-0.944	0.345[b]
STT-B	10 (-33, 32.5)	17 (-17.5, 50.5)	-1.519	0.129[b]	-25.5 (-54, 17.5)	-15 (-42, 16)	-0.333	0.739[b]
GDS-15	-1 (-2, 1)	0 (-1, 1)	-1.252	0.210[b]	0 (-1.25, 1.25)	1 (-2, 2)	-0.505	0.614[b]
SAS	0 (-4.25, 3.75)	1.25 (-5, 7.5)	-1.586	0.113[b]	0 (-3.75, 2.81)	1.25 (-6.25, 7.5)	-0.639	0.523[b]
UCLA loneliness scale	-3 (-10.5, 0)	0.5 (-6, 6)	-2.654	0.008[b]	-3 (-10, 2.75)	-1 (-7, 6)	-0.639	0.523[b]
QoL-AD	1.66 ± 6.21	2.26 ± 6.45	-0.569	0.570[a]	5.5 ± 8.68	5.93 ± 6.25	-0.145	0.886[a]
ADL	0 (0, 1)	0 (0, 1)	-0.572	0.567[b]	0 (0, 1)	1 (0, 1)	-0.453	0.651[b]
BBS	0 (-2, 0)	0 (-2, 1)	-0.176	0.860[b]	0 (-3.25, 1.25)	-2 (-2, 1)	-0.505	0.614[b]
HPLP-II	13.85 ± 27.56	16.21 ± 32.42	-0.466	0.642[a]	19.3 ± 42.25	16.27 ± 16.59	0.252	0.803[a]
SARHP	6 (-7.5, 24.5)	-1.5 (-20.5, 11.75)	-2.338	0.019[b]	-9.5 (-28, 11)	1 (-15, 14)	-0.805	0.421[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 4. Between-Group Comparisons of Outcome Changes by Residence Status Subgroup

Variables	Living alone				Not living alone			
	Intervention group (n=7)	Control group (n=7)	*t/Z*	*P*	Intervention group (n=76)	Control group (n=76)	*t/Z*	*P*
MoCA	-0.29 ± 2.36	1.43 ± 2.37	-1.356	0.200[a]	0.38 ± 2.96	-0.83 ± 2.98	2.513	0.013[a]
AVLT-short delayed recall	-0.14 ± 6.23	3 ± 6.71	-0.908	0.382[a]	0.67 ± 5.2	-0.62 ± 4.35	1.659	0.099[a]
AVLT-long delayed recall	0.43 ± 2.94	0.14 ± 1.95	0.214	0.834[a]	-0.08 ± 2.93	-0.84 ± 2.38	1.760	0.080[a]
AVLT-recognition recall	1 (-1, 2)	0 (-2, 1)	-0.646	0.518[b]	0 (-1.75, 1)	0 (-1, 2)	-0.197	0.843[b]
ROCFT-immediate recall	-0.43 ± 9.54	-0.71 ± 8.86	0.058	0.955[a]	0.42 ± 7.91	-2.87 ± 8.13	2.527	0.013[a]
ROCFT-long delayed recall	2.14 ± 6.67	0.71 ± 7.7	0.371	0.717[a]	0.2 ± 7.88	-3.45 ± 8.16	2.802	0.006[a]
ROCFT-copy time	-32 (-93, 42)	-18 (-88, 28)	-0.192	0.848[b]	7.5 (-60, 88.75)	21 (-20.5, 70)	-0.704	0.482[b]
VFT	0.14 ± 1.46	-0.14 ± 2.19	0.287	0.779[a]	0.2 ± 3.95	-0.29 ± 3.65	0.789	0.432[a]
BNT	2 (1, 4)	0 (-1, 4)	-0.898	0.369[b]	1 (-2, 3)	0 (-2, 2)	-1.020	0.308[b]
STT-A	-6 (-23, 4)	2 (-5, 15)	-1.087	0.277[b]	0 (-10.75, 10.75)	6 (-10, 22)	-1.539	0.124[b]
STT-B	-51 (-68, -9)	7 (-42, 22)	-1.597	0.110[b]	10 (-29, 34)	11 (-19.75, 48.75)	-0.934	0.350[b]
GDS-15	-1 (-4, 0)	0 (-4, 1)	-0.720	0.471[b]	0 (-1.75, 1)	0 (-1, 1.75)	-1.223	0.221[b]
SAS	1.25 (-3.75, 3.75)	2.5 (-11.25, 7.5)	-0.064	0.949[b]	-0.25 (-4.5, 3.75)	1.25 (-5, 7.5)	-1.720	0.086[b]
UCLA loneliness scale	-5 (-7, 2)	-3 (-6, 6)	-0.321	0.748[b]	-2.5 (-10.75, 0)	0.5 (-6, 6)	-2.663	0.008[b]
QoL-AD	0.86 ± 8.43	3.71 ± 7.72	-0.661	0.521[a]	2.24 ± 6.48	2.86 ± 6.47	-0.589	0.557[a]
ADL	0 (0, 1)	0 (0, 0)	-0.523	0.601[b]	0 (0, 1)	0 (0, 1)	-0.118	0.906[b]
BBS	0 (-3, 1)	0 (-2, 2)	-0.452	0.651[b]	0 (-2, 0)	0 (-2, 0.75)	-0.284	0.776[b]
HPLP-II	27 ± 25.77	9.43 ± 30.03	1.175	0.263[a]	13.36 ± 29.63	16.84 ± 30.22	-0.718	0.474[a]
SARHP	-6 (-58, 21)	-6 (-30, 32)	-0.256	0.798[b]	5 (-8.75, 24)	0 (-18, 11.75)	-2.077	0.038[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Ⅱ. lifestyle habits and social participation factors

Table 5. Between-Group Comparisons of Outcome Changes by Smoking Subgroup

Variables	Never				Used to/Still			
	Intervention group (n=73)	Control group (n=72)	*t/Z*	*P*	Intervention group (n=10)	Control group (n=11)	*t/Z*	*P*
MoCA	0.47 ± 2.95	-0.68 ± 2.9	2.359	0.020[a]	-0.7 ± 2.45	-0.36 ± 3.67	-0.244	0.810[a]
AVLT-short delayed recall	0.77 ± 5.47	-0.1 ± 4.84	1.007	0.316[a]	-0.6 ± 3.13	-1.73 ± 2.97	0.846	0.408[b]
AVLT-long delayed recall	0.04 ± 2.97	-0.75 ± 2.42	1.756	0.081[a]	-0.6 ± 2.55	-0.82 ± 1.99	0.220	0.828[a]
AVLT-recognition recall	0 (-1.5, 1)	0 (-1, 1)	-0.042	0.966[b]	1 (-1.25, 3)	1 (-1, 2)	-0.036	0.972[b]
ROCFT-immediate recall	0.68 ± 7.94	-2.4 ± 8.19	2.305	0.023[a]	-2.1 ± 8.4	-4.55 ± 8.14	0.677	0.506[a]
ROCFT-long delayed recall	0.37 ± 7.56	-2.78 ± 8.26	2.394	0.018[a]	0.3 ± 9.6	-5.18 ± 7.45	1.469	0.158[a]
ROCFT-copy time	9 (-59, 78.5)	10.5 (-20.5, 69.5)	-0.579	0.562[b]	0 (-72.5, 86.75)	21 (-62, 70)	-0.634	0.526[b]
VFT	0.44 ± 3.48	-0.28 ± 3.62	1.214	0.227[a]	-1.6 ± 5.54	-0.27 ± 3.13	-0.684	0.502[a]
BNT	2 (-2, 3)	-0.5 (-2, 2)	-1.786	0.074[b]	-0.5 (-2.25, 0.25)	2 (-2, 4)	-0.993	0.321[b]
STT-A	-1 (-11, 8)	6 (-8, 22)	-2.270	0.023[b]	10.5 (-4.75, 24)	1 (-17, 20)	-1.058	0.290[b]
STT-B	8 (-38.5, 30.5)	11 (-20.75, 48)	-1.240	0.215[b]	10 (-37.75, 35.25)	-1 (-11, 45)	-0.141	0.888[b]
GDS-15	0 (-1, 1)	0 (-1, 1.75)	-1.087	0.277[b]	-1 (-4.25, 0)	0 (-1, 1)	-1.214	0.225[b]
SAS	0 (-3.25, 3.75)	1.25 (-5, 7.5)	-1.404	0.160[b]	-3.13 (-11.88, 3.44)	1.25 (-5.39, 8.75)	-0.916	0.359[b]
UCLA loneliness scale	-2 (-9.5, 2)	0.5 (-6, 6)	-2.362	0.018[b]	-8 (-18.5, 0)	-1 (-7, 1)	-1.517	0.129[b]
QoL-AD	1.78 ± 6.82	3.29 ± 6.44	-1.371	0.173[a]	4.6 ± 4.3	0.55 ± 6.93	1.590	0.128[a]
ADL	0 (0, 1)	0 (0, 1)	-0.062	0.950[b]	0 (0, 1)	0 (0, 1)	-1.038	0.299[b]
BBS	0 (-2, 0)	0 (-2, 1)	-0.016	0.987[b]	0 (-2, 0)	0 (-2, 0)	-0.374	0.708[b]
HPLP-II	14.41 ± 30.51	17.4 ± 31.28	-0.583	0.561[a]	15.2 ± 20.98	8.45 ± 20.11	0.752	0.461[a]
SARHP	5 (-15, 24)	0 (-21, 13.75)	-1.481	0.139[b]	4.5 (-2.5, 26.25)	-4 (-15, 2)	-1.869	0.062[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 6.Between-Group Comparisons of Outcome Changes by Alcohol Consumption Subgroup

Variables	Never				Used to/Still			
	Intervention group (n=65)	Control group (n=68)	*t/Z*	*P*	Intervention group (n=18)	Control group (n=15)	*t/Z*	*P*
MoCA	0.55 ± 3.04	-0.71 ± 2.9	2.444	0.016[a]	-0.5 ± 2.26	-0.33 ± 3.44	-0.167	0.868[a]
AVLT-short delayed recall	0.66 ± 5.61	-0.32 ± 4.82	1.088	0.279[a]	0.39 ± 3.82	-0.27 ± 3.94	0.484	0.632[a]
AVLT-long delayed recall	0.05 ± 3.02	-0.71 ± 2.32	1.612	0.109[a]	-0.33 ± 2.57	-1 ± 2.56	0.743	0.463[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 1)	-0.460	0.645[b]	0.5 (-2, 1.5)	1 (0, 2)	-0.822	0.411[b]
ROCFT-immediate recall	0.78 ± 7.92	-2.53 ± 8.58	2.312	0.022[a]	-1.22 ± 8.3	-3.4 ± 6.14	0.842	0.407[a]
ROCFT-long delayed recall	0.22 ± 7.83	-2.78 ± 8.56	2.103	0.037[a]	0.89 ± 7.73	-4.53 ± 6.03	2.211	0.035[a]
ROCFT-copy time	6 (-59, 78.5)	13 (-20.5, 67.25)	-0.329	0.742[b]	2 (-72.5, 86.75)	42 (-41, 71)	-1.013	0.311[b]
VFT	0.63 ± 3.43	-0.49 ± 3.73	1.793	0.075[a]	-1.39 ± 4.68	0.67 ± 2.41	-1.537	0.134[a]
BNT	1 (-2, 3)	-1 (-2, 2)	-1.454	0.146[b]	1 (-0.25, 2)	2 (-2, 4)	-0.728	0.467[b]
STT-A	-2 (-11.5, 8)	5.5 (-9.5, 22)	-2.202	0.028[b]	7 (-2.25, 24)	7 (-11, 20)	-0.489	0.625[b]
STT-B	10 (-41, 30.5)	9.5 (-20.75, 43.75)	-0.916	0.360[b]	3.5 (-17.5, 35.25)	25 (-11, 69)	-1.013	0.311[b]
GDS-15	0 (-1, 1)	0 (-1.75, 1.75)	-1.043	0.297[b]	-0.5 (-4.25, 2)	0 (-1, 1)	-0.967	0.334[b]
SAS	0 (-3.25, 3.75)	1.88 (-5, 7.5)	-1.269	0.205[b]	-2.5 (-11.88, 1.88)	0 (-5.39, 7.5)	-1.177	0.239[b]
UCLA loneliness scale	-1 (-8.5, 2)	0.5 (-6.75, 6)	-1.984	0.047[b]	-8 (-16, 0)	0 (-3, 3)	-2.212	0.027[b]
QoL-AD	1.91 ± 6.94	3.4 ± 6.37	-1.291	0.199[a]	2.89 ± 5.38	0.8 ± 7.07	0.963	0.343[a]
ADL	0 (0, 1)	0 (0, 1)	-0.502	0.615[b]	0 (0, 1.25)	0 (0, 0)	-1.792	0.073[b]
BBS	0 (-2, 0)	-0.5 (-2, 1)	-0.311	0.756[b]	-0.5 (-2, 0)	0 (-2, 0)	-0.377	0.706[b]
HPLP-II	15.63 ± 31.26	18.46 ± 31.58	-0.518	0.605[a]	10.44 ± 21.81	6.07 ± 19.91	0.597	0.555[a]
SARHP	4 (-17, 24)	0 (-21, 17.75)	-1.035	0.300[b]	7.5 (-0.5, 24.25)	-1 (-17, 3)	-2.477	0.013[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 7. Between-Group Comparisons of Outcome Changes by Physical Activities Subgroup

Variables	Never/Occasionally				Often/Active Participation			
	Intervention group (n=20)	Control group (n=19)	*t/Z*	*P*	Intervention group (n=63)	Control group (n=64)	*t/Z*	*P*
MoCA	-0.1 ± 2.38	-1.21 ± 2.23	1.502	0.141[a]	0.46 ± 3.06	-0.47 ± 3.17	1.679	0.096[a]
AVLT-short delayed recall	1.65 ± 4.92	0.84 ± 5.12	0.502	0.619[a]	0.27 ± 5.35	-0.66 ± 4.49	1.058	0.292[a]
AVLT-long delayed recall	-0.6 ± 3.27	-0.11 ± 2.21	-0.551	0.585[a]	0.14 ± 2.8	-0.95 ± 2.38	2.376	0.019[a]
AVLT-recognition recall	0 (-1.75, 1)	0 (-3, 2)	-0.398	0.691[b]	0 (-1, 2)	0 (-1, 1)	-0.288	0.774[b]
ROCFT-immediate recall	0.2 ± 10.31	-2 ± 10.62	0.656	0.516[a]	0.4 ± 7.21	-2.89 ± 7.37	2.540	0.012[a]
ROCFT-long delayed recall	-1.3 ± 7.14	-2 ± 9.43	0.262	0.795[a]	0.89 ± 7.94	-3.42 ± 7.79	3.088	0.002[a]
ROCFT-copy time	52 (-83, 122.25)	24 (-14, 57)	-0.703	0.482[b]	0 (-61, 52)	10.5 (-40, 70)	-1.234	0.217[b]
VFT	0 ± 3.2	-0.89 ± 3.77	0.801	0.428[a]	0.25 ± 4	-0.09 ± 3.48	0.523	0.602[a]
BNT	1 (-0.75, 2.75)	1 (-1, 3)	-0.028	0.977[b]	1 (-3, 3)	-1 (-2, 2)	-1.092	0.275[b]
STT-A	-1.5 (-7.75, 10.75)	6 (-8, 28)	-1.069	0.285[b]	0 (-11, 10)	5.5 (-10, 21.75)	-1.285	0.199[b]
STT-B	-6.5 (-41.75, 44)	19 (-49, 34)	-0.281	0.779[b]	10 (-37, 30)	9.5 (-16.5, 48.75)	-1.244	0.213[b]
GDS-15	-1 (-5.5, 0.75)	0 (-2, 1)	-1.061	0.289[b]	0 (-1, 1)	0 (-1, 1.75)	-1.104	0.269[b]
SAS	0.5 (-7.19, 3.44)	2.5 (-5, 7.5)	-0.816	0.414[b]	-1.25 (-3.75, 3.75)	1.25 (-5, 7.5)	-1.461	0.144[b]
UCLA loneliness scale	-6.5 (-16, 1.5)	0 (-8, 4)	-1.212	0.225[b]	-2 (-8, 0)	1 (-6, 6)	-2.361	0.018[b]
QoL-AD	3.45 ± 6.64	2.16 ± 6.31	0.622	0.538[a]	1.7 ± 6.6	3.16 ± 6.63	-1.242	0.217[a]
ADL	0.5 (0, 2)	0 (0, 1)	-0.772	0.440[b]	0 (0, 1)	0 (0, 1)	-0.111	0.912[b]
BBS	0 (-1.75, 0)	0 (-2, 2)	-1.098	0.272[b]	0 (-2, 0)	0 (-2, 0)	-0.763	0.445[b]
HPLP-II	19 ± 27.76	23.53 ± 32.82	-0.466	0.644[a]	13.08 ± 30.01	14.05 ± 29.16	-0.184	0.854[a]
SARHP	7.5 (-7.5, 26.75)	1 (-23, 39)	-0.520	0.603[b]	4 (-17, 24)	-0.5 (-18.75, 10.5)	-1.763	0.078[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 8. Between-Group Comparisons of Outcome Changes by Leisure Intellectual Activities Subgroup

Variables	Never/Occasionally				Often/Active Participation			
	Intervention group (n=51)	Control group (n=52)	*t/Z*	*P*	Intervention group (n=32)	Control group (n=31)	*t/Z*	*P*
MoCA	0.43 ± 2.73	-0.38 ± 3.05	1.430	0.156[a]	0.16 ± 3.21	-1.06 ± 2.87	1.587	0.118[a]
AVLT-short delayed recall	1.39 ± 5.44	-0.17 ± 5.07	1.511	0.134[a]	-0.66 ± 4.76	-0.55 ± 3.91	-0.098	0.922[a]
AVLT-long delayed recall	-0.04 ± 3.24	-0.62 ± 2.43	1.023	0.309[a]	-0.03 ± 2.38	-1 ± 2.25	1.660	0.102[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 1)	-0.280	0.779[b]	0 (-2, 1)	0 (-1, 2)	-0.389	0.697[b]
ROCFT-immediate recall	-0.45 ± 7.6	-2.67 ± 8.54	1.393	0.167[a]	1.63 ± 8.56	-2.71 ± 7.62	2.121	0.038[a]
ROCFT-long delayed recall	-0.47 ± 6.82	-2.52 ± 8.03	1.395	0.166[a]	1.69 ± 9.03	-4.06 ± 8.41	2.613	0.011[a]
ROCFT-copy time	0 (-66, 60)	21 (-30.75, 65)	-0.848	0.397[b]	16.5 (-60, 96.25)	7 (-37, 82)	-0.316	0.752[b]
VFT	0 ± 3.63	-0.52 ± 3.7	0.719	0.474[a]	0.5 ± 4.1	0.13 ± 3.28	0.396	0.694[a]
BNT	1 (-1, 3)	-0.5 (-2, 2)	-1.536	0.125[b]	0 (-3, 3.75)	0 (-2, 2)	-0.076	0.939[b]
STT-A	1 (-8, 12)	0.5 (-11, 19.75)	-0.145	0.885[b]	-2.5 (-22, 4)	9 (-2, 22)	-2.744	0.006[b]
STT-B	10 (-43, 31)	9.5 (-20.75, 38.5)	-0.205	0.838[b]	-1 (-37.75, 18)	19 (-15, 59)	-1.685	0.092[b]
GDS-15	0 (-2, 1)	0 (-2, 1)	-0.316	0.752[b]	-0.5 (-1.75, 1)	1 (-1, 2)	-2.036	0.042[b]
SAS	-0.5 (-4.75, 2.5)	0 (-6.04, 7.5)	-0.436	0.663[b]	0 (-2.69, 3.75)	2.5 (0, 7.5)	-2.149	0.032[b]
UCLA loneliness scale	-2 (-11, 2)	-1 (-8.75, 4.75)	-0.370	0.711[b]	-4.5 (-10, 0)	4 (0, 7)	-3.974	<0.001[b]
QoL-AD	3.08 ± 6.8	3.35 ± 7.26	-0.193	0.847[a]	0.59 ± 6.1	2.23 ± 5.12	-1.148	0.255[a]
ADL	0 (0, 1)	0 (0, 1)	-0.532	0.595[b]	0 (0, 1)	0 (0, 1)	-0.189	0.850[b]
BBS	0 (-1, 0)	0 (-2, 1)	-0.646	0.519[b]	0 (-2, 0)	0 (-2, 0)	-0.678	0.498[b]
HPLP-II	11.86 ± 28.42	18.04 ± 29.18	-1.088	0.279[a]	18.72 ± 30.95	13.16 ± 31.82	0.703	0.485[a]
SARHP	7 (-6, 24)	0.5 (-16.5, 23)	-1.230	0.219[b]	3.5 (-21.5, 24)	-4 (-21, 3)	-1.396	0.163[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table9. Between-Group Comparisons of Outcome Changes by Organized Group Activities Subgroup

Variables	Never/Occasionally				Often/Active Participation			
	Intervention group (n=57)	Control group (n=63)	*t/Z*	*P*	Intervention group (n=26)	Control group (n=20)	*t/Z*	*P*
MoCA	0.19 ± 2.93	-0.43 ± 2.91	1.165	0.246[a]	0.62 ± 2.9	-1.3 ± 3.21	2.119	0.040[a]
AVLT-short delayed recall	0.67 ± 5.38	-0.35 ± 4.98	1.075	0.285[a]	0.46 ± 5.07	-0.2 ± 3.53	0.497	0.621[a]
AVLT-long delayed recall	0.04 ± 2.9	-0.62 ± 2.36	1.360	0.176[a]	-0.19 ± 3.01	-1.2 ± 2.35	1.235	0.223[a]
AVLT-recognition recall	0 (-2, 1)	0 (-1, 2)	-1.162	0.245[b]	0 (-1, 2)	-1 (-2.75, 0)	-1.862	0.063[b]
ROCFT-immediate recall	-0.19 ± 7.94	-3.25 ± 8.29	2.061	0.042[a]	1.54 ± 8.16	-0.9 ± 7.66	1.031	0.308[a]
ROCFT-long delayed recall	0.11 ± 7.45	-3.06 ± 8.12	2.220	0.028[a]	0.92 ± 8.55	-3.2 ± 8.5	1.626	0.111[a]
ROCFT-copy time	9 (-67, 90.5)	21 (-41, 67)	-0.055	0.956[b]	-7.5 (-62.25, 60.25)	10.5 (-4.5, 96.25)	-1.418	0.156[b]
VFT	-0.07 ± 3.78	-0.38 ± 3.36	0.476	0.635[a]	0.77 ± 3.85	0.05 ± 4.14	0.608	0.546[a]
BNT	1 (-2.5, 3)	0 (-2, 2)	-0.330	0.741[b]	2 (-1.25, 4)	-2 (-3, 2)	-1.592	0.111[b]
STT-A	1 (-11, 11)	6 (-8, 22)	-1.430	0.153[b]	-1.5 (-11.5, 4.75)	3.5 (-16, 21.75)	-0.554	0.579[b]
STT-B	10 (-37.5, 30)	8 (-21, 43)	-0.426	0.670[b]	-3.5 (-45.5, 38)	27.5 (-10.25, 67)	-1.895	0.058[b]
GDS-15	0 (-2, 1)	0 (-1, 1)	-1.115	0.265[b]	-0.5 (-1, 0.25)	0 (-1.75, 2)	-0.923	0.356[b]
SAS	0 (-5.63, 4.38)	1.25 (-5, 7.5)	-1.157	0.247[b]	-1.25 (-2.5, 1.56)	1.25 (-1.25, 6.25)	-1.536	0.125[b]
UCLA loneliness scale	-2 (-9.5, 2.5)	0 (-7, 6)	-1.315	0.188[b]	-4.5 (-11, 0)	3.5 (0, 5.75)	-3.235	0.001[b]
QoL-AD	2.4 ± 6.08	3.44 ± 6.43	-0.909	0.365[a]	1.5 ± 7.75	1.3 ± 6.75	0.092	0.927[a]
ADL	0 (0, 1)	0 (0, 1)	-0.398	0.690[b]	0 (0, 1)	0 (0, 1)	-0.134	0.893[b]
BBS	0 (-2, 0)	-1 (-2, 1)	-0.594	0.552[b]	0 (-2, 0)	0 (-2, 0.75)	-0.854	0.393[b]
HPLP-II	15.19 ± 29.85	15.35 ± 26.25	-0.031	0.976[a]	13 ± 29	18.95 ± 40.63	-0.580	0.565[a]
SARHP	6 (-8.5, 26)	1 (-15, 23)	-0.886	0.376[b]	4 (-18, 22.5)	-15.5 (-27, 1.75)	-2.340	0.019[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 10. Between-Group Comparisons of Outcome Changes by Children interactions Subgroup

Variables	Rarely/Occasionally				Often			
	Intervention group (n=15)	Control group (n=19)	*t/Z*	*P*	Intervention group (n=68)	Control group (n=64)	*t/Z*	*P*
MoCA	1.27 ± 2.25	-0.37 ± 3.27	1.650	0.109[a]	0.12 ± 3.01	-0.72 ± 2.92	1.619	0.108[a]
AVLT-short delayed recall	1.2 ± 3.9	-0.74 ± 4.51	1.319	0.196[a]	0.47 ± 5.52	-0.19 ± 4.72	0.734	0.464[a]
AVLT-long delayed recall	-0.07 ± 2.46	-1.16 ± 2.41	1.298	0.203[a]	-0.03 ± 3.03	-0.64 ± 2.35	1.291	0.199[a]
AVLT-recognition recall	1 (-2, 2)	0 (-3, 2)	-0.982	0.326[b]	0 (-1, 1)	0 (-1, 1.75)	-0.514	0.607[b]
ROCFT-immediate recall	-2.07 ± 8.9	-1.68 ± 8.83	-0.125	0.901[a]	0.88 ± 7.76	-2.98 ± 8	2.818	0.006[a]
ROCFT-long delayed recall	2.13 ± 7.66	-2.37 ± 8.47	1.604	0.119[a]	-0.03 ± 7.79	-3.31 ± 8.12	2.371	0.019[a]
ROCFT-copy time	-37 (-93, 41)	14 (-21, 88)	-1.544	0.123[b]	11.5 (-54, 88.75)	20 (-36.5, 68.75)	-0.157	0.875[b]
VFT	-2.13 ± 4.44	-0.95 ± 3.5	-0.872	0.390[a]	0.71 ± 3.48	-0.08 ± 3.56	1.280	0.203[a]
BNT	0 (-1, 2)	0 (-2, 3)	-0.035	0.972[b]	1 (-2, 3)	-0.5 (-2, 2)	-1.409	0.159[b]
STT-A	4 (-16, 17)	9 (-8, 22)	-1.041	0.298[b]	0 (-9.75, 9.5)	4.5 (-10.75, 20.75)	-1.330	0.184[b]
STT-B	28 (-51, 51)	8 (-15, 61)	-0.277	0.781[b]	7 (-35.75, 22.75)	11 (-25.5, 43.75)	-1.296	0.195[b]
GDS-15	-1 (-4, 1)	0 (-2, 1)	-0.754	0.451[b]	0 (-1, 1)	0 (-1, 2)	-1.278	0.201[b]
SAS	1.25 (0, 6.25)	1.25 (-5, 5)	-0.888	0.375[b]	-1.25 (-5, 2.5)	1.25 (-5, 7.5)	-2.076	0.038[b]
UCLA loneliness scale	-6 (-11, 0)	0 (-3, 10)	-1.703	0.089[b]	-2 (-10, 1.5)	0 (-6, 5.75)	-2.054	0.040[b]
QoL-AD	2.93 ± 5.96	1.89 ± 6.31	0.488	0.629[a]	1.94 ± 6.78	3.23 ± 6.62	-1.108	0.270[a]
ADL	0 (0, 1)	0 (0, 1)	-0.094	0.925[b]	0 (0, 1)	0 (0, 1)	-0.349	0.727[b]
BBS	-1 (-2, 1)	0 (-1, 2)	-0.596	0.551[b]	0 (-2, 0)	-0.5 (-2, 0)	-0.513	0.608[b]
HPLP-II	14.27 ± 26.74	15.74 ± 36.44	-0.131	0.897[a]	14.56 ± 30.17	16.36 ± 28.28	-0.353	0.724[a]
SARHP	4 (-27, 24)	-4 (-29, 7)	-0.694	0.488[b]	5.5 (-8.75, 24)	0 (-16.75, 12.75)	-1.721	0.085[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 11. Between-Group Comparisons of Outcome Changes by Friends interactions Subgroup

Variables	Rarely/Occasionally				Often			
	Intervention group (n=15)	Control group (n=15)	*t/Z*	*P*	Intervention group (n=68)	Control group (n=68)	*t/Z*	*P*
MoCA	0.33 ± 2.44	0.13 ± 2.47	0.223	0.825[a]	0.32 ± 3.02	-0.81 ± 3.08	2.166	0.032[a]
AVLT-short delayed recall	0.33 ± 3.83	0.2 ± 4.54	0.087	0.931[a]	0.66 ± 5.54	-0.43 ± 4.7	1.235	0.219[a]
AVLT-long delayed recall	0.53 ± 2.72	0.2 ± 1.74	0.400	0.692[a]	-0.16 ± 2.97	-0.97 ± 2.43	1.739	0.084[a]
AVLT-recognition recall	1 (0, 1)	1 (-1, 2)	-0.530	0.596[b]	0 (-2, 1)	0 (-1, 1)	-0.073	0.942[b]
ROCFT-immediate recall	-2.53 ± 7.61	-0.93 ± 6.71	-0.610	0.546[a]	0.99 ± 8	-3.07 ± 8.44	2.878	0.005[a]
ROCFT-long delayed recall	-1 ± 6.41	-0.87 ± 7.43	-0.053	0.958[a]	0.66 ± 8.05	-3.59 ± 8.28	3.036	0.003[a]
ROCFT-copy time	-13 (-66, 42)	55 (-2, 88)	-1.929	0.054[b]	7.5 (-60, 88.75)	10.5 (-36.5, 67.75)	-0.078	0.938[b]
VFT	-2.07 ± 4.62	-0.67 ± 3.22	-0.963	0.344[a]	0.69 ± 3.44	-0.19 ± 3.63	1.456	0.148[a]
BNT	1 (-4, 3)	1 (-2, 3)	-0.771	0.440[b]	1 (-2, 3)	-0.5 (-2, 2)	-1.753	0.080[b]
STT-A	4 (-9, 22)	1 (-11, 22)	-0.457	0.648[b]	-1 (-11, 9.5)	6 (-8, 21.75)	-2.148	0.032[b]
STT-B	18 (-54, 45)	-6 (-49, 48)	-0.270	0.787[b]	9 (-35.75, 26.25)	11 (-16.5, 47.5)	-1.674	0.094[b]
GDS-15	0 (-1, 1)	0 (-2, 1)	-0.105	0.916[b]	-1 (-2, 1)	0 (-1, 1.75)	-1.509	0.131[b]
SAS	1.25 (-2.5, 6.25)	1.25 (-6.25, 5)	-0.770	0.441[b]	-1.25 (-5, 3.75)	1.25 (-4.69, 7.5)	-2.166	0.030[b]
UCLA loneliness scale	0 (-5, 3)	-4 (-25, 6)	-1.247	0.212[b]	-4.5 (-11.75, 0)	1 (-4.5, 6)	-3.553	<0.001[b]
QoL-AD	2.4 ± 5.28	1.6 ± 7.04	0.352	0.727[a]	2.06 ± 6.91	3.22 ± 6.43	-1.015	0.312[a]
ADL	0 (0, 0)	0 (0, 1)	-1.872	0.061[b]	0 (0, 1)	0 (0, 1)	-1.293	0.196[b]
BBS	0 (-2, 1)	0 (-4, 2)	-0.273	0.785[b]	0 (-2, 0)	-1 (-2, 0)	-0.368	0.713[b]
HPLP-II	13.93 ± 30.49	5.53 ± 30.38	0.756	0.456[a]	14.63 ± 29.42	18.57 ± 29.74	-0.777	0.439[a]
SARHP	-14 (-27, 24)	3 (-6, 40)	-0.747	0.455[b]	5.5 (-6, 24)	-2 (-20.5, 10.5)	-2.706	0.007[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Ⅲ. Medical history information

Table 12. Between-Group Comparisons of Outcome Changes by Stroke Subgroup

Variables	No				Yes			
	Intervention group (n=75)	Control group (n=76)	*t/Z*	*P*	Intervention group (n=8)	Control group (n=7)	*t/Z*	*P*
MoCA	0.33 ± 2.99	-0.82 ± 3	2.358	0.020[a]	0.25 ± 2.19	1.29 ± 2.14	-0.924	0.372[a]
AVLT-short delayed recall	0.57 ± 5.47	-0.36 ± 4.78	1.112	0.268[a]	0.88 ± 2.64	0.14 ± 3.18	0.487	0.634[a]
AVLT-long delayed recall	-0.04 ± 2.97	-0.82 ± 2.38	1.775	0.078[a]	0 ± 2.62	-0.14 ± 2.19	0.114	0.911[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 1)	-0.714	0.475[b]	-2.5 (-3.75, 0)	1 (-3, 3)	-1.945	0.052[b]
ROCFT-immediate recall	0.23 ± 7.89	-2.57 ± 8.22	2.130	0.035[a]	1.5 ± 9.49	-4 ± 8.02	1.202	0.251[a]
ROCFT-long delayed recall	0.59 ± 7.51	-2.86 ± 8.26	2.679	0.008[a]	-1.75 ± 10.25	-5.71 ± 6.97	0.862	0.404[a]
ROCFT-copy time	0 (-77, 72)	10.5 (-36.5, 68.75)	-1.079	0.280[b]	56.5 (15.5, 147.5)	57 (7, 89)	-0.521	0.602[b]
VFT	0.09 ± 3.86	-0.39 ± 3.55	0.809	0.420[a]	1.13 ± 3.27	1 ± 3.46	0.072	0.944[a]
BNT	1 (-2, 3)	0 (-2, 2)	-1.391	0.164[b]	-1 (-2.75, 2.25)	0 (-3, 2)	-0.117	0.907[b]
STT-A	0 (-10, 11)	6 (-9.5, 21.75)	-1.576	0.115[b]	-5 (-17.75, 7)	-7 (-10, 25)	-1.157	0.247[b]
STT-B	4 (-39, 35)	9.5 (-20.75, 48)	-1.239	0.215[b]	11.5 (-26.5, 17)	11 (-19, 34)	-0.579	0.562[b]
GDS-15	-1 (-2, 1)	0 (-1, 1.75)	-1.522	0.128[b]	0 (-1.75, 1.75)	0 (-2, 1)	-0.117	0.907[b]
SAS	-0.5 (-4.75, 3.75)	1.25 (-5, 7.5)	-1.450	0.147[b]	0.63 (-2.69, 8.75)	3.75 (2.5, 7.5)	-1.044	0.296[b]
UCLA loneliness scale	-4 (-11, 0)	0 (-6, 6)	-2.753	0.006[b]	0 (-7.75, 2.75)	1 (-19, 4)	-0.290	0.772[b]
QoL-AD	2.09 ± 6.79	2.84 ± 6.68	-0.683	0.496[a]	2.38 ± 5.04	3.86 ± 4.88	-0.577	0.574[a]
ADL	0 (0, 1)	0 (0, 1)	-0.494	0.621[b]	0 (0, 1)	1 (0, 1)	-0.735	0.462[b]
BBS	0 (-2, 0)	0 (-2, 1)	-0.239	0.811[b]	-1 (-2, 0.75)	0 (-2, 1)	-0.303	0.762[b]
HPLP-II	15.85 ± 28.89	14.39 ± 29.75	0.306	0.760[a]	1.88 ± 33.48	36 ± 28.55	-2.106	0.055[a]
SARHP	5 (-8, 22)	0 (-18, 12.75)	-1.597	0.110[b]	5.5 (-16.75, 31)	-7 (-52, 0)	-1.157	0.247[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 13. Between-Group Comparisons of Outcome Changes by Diabetes Mellitus Subgroup

Variables	No				Yes			
	Intervention group (n=60)	Control group (n=58)	*t/Z*	*P*	Intervention group (n=23)	Control group (n=25)	*t/Z*	*P*
MoCA	0.18 ± 2.97	-0.72 ± 2.86	1.692	0.093[a]	0.7 ± 2.79	-0.44 ± 3.32	1.278	0.208[a]
AVLT-short delayed recall	0.23 ± 4.76	-0.88 ± 4.52	1.301	0.196[a]	1.57 ± 6.37	1 ± 4.78	0.349	0.728[a]
AVLT-long delayed recall	-0.15 ± 3.12	-0.83 ± 2.39	1.323	0.189[a]	0.26 ± 2.36	-0.6 ± 2.33	1.272	0.210[a]
AVLT-recognition recall	0 (-1.75, 1)	0 (-2, 1.25)	-0.076	0.939[b]	0 (-1, 1)	0 (-1, 2)	-0.063	0.950[b]
ROCFT-immediate recall	0.27 ± 7.53	-3.9 ± 7.82	2.947	0.004[a]	0.57 ± 9.29	0.12 ± 8.42	0.174	0.862[a]
ROCFT-long delayed recall	0.27 ± 8.01	-3.59 ± 8.21	2.580	0.011[a]	0.61 ± 7.26	-1.96 ± 8.08	1.155	0.254[a]
ROCFT-copy time	9.5 (-74.25, 91.5)	10.5 (-18.25, 70.25)	-0.396	0.692[b]	-15 (-56, 42)	23 (-64, 69.5)	-0.753	0.451[b]
VFT	0.38 ± 3.76	-0.59 ± 3.47	1.452	0.149[a]	-0.3 ± 3.94	0.44 ± 3.66	-0.679	0.501[a]
BNT	0.5 (-2.75, 3)	0 (-2, 2)	-0.308	0.758[b]	2 (-1, 4)	0 (-2, 2.5)	-1.867	0.062[b]
STT-A	-1 (-11.75, 8)	6 (-10, 22.75)	-2.068	0.039[b]	1 (-6, 12)	1 (-7.5, 19)	-0.176	0.861[b]
STT-B	3.5 (-38.75, 26.25)	7 (-22.5, 45.75)	-1.015	0.310[b]	13 (-37, 38)	22 (-11.5, 56)	-0.805	0.421[b]
GDS-15	-1 (-2, 1)	0 (-1, 2)	-2.341	0.019[b]	0 (-1, 2)	-1 (-2, 1)	-1.036	0.300[b]
SAS	0.5 (-3.5, 3.75)	1.88 (-2.5, 7.5)	-1.491	0.136[b]	-2.5 (-6.25, 1.25)	1.25 (-8.13, 7.5)	-0.558	0.577[b]
UCLA loneliness scale	-4.5 (-10.75, 0)	0 (-7, 6)	-2.482	0.013[b]	-2 (-10, 2)	1 (-4.5, 5.5)	-0.909	0.363[b]
QoL-AD	2.6 ± 6.44	1.69 ± 6.4	0.770	0.443[a]	0.87 ± 7.03	5.8 ± 6.02	-2.615	0.012[a]
ADL	0 (0, 1)	0 (0, 1)	-0.605	0.545[b]	0 (0, 0)	0 (0, 1)	-0.546	0.585[b]
BBS	0 (-2, 0)	0 (-2, 1)	-0.006	0.996[b]	0 (-1, 0)	0 (-2, 1)	-0.233	0.816[b]
HPLP-II	12.93 ± 28.52	16.84 ± 30.21	-0.723	0.471[a]	18.61 ± 31.96	14.76 ± 30.4	0.428	0.671[a]
SARHP	4 (-12, 23.5)	-1.5 (-21.5, 12.5)	-1.551	0.121[b]	6 (-13, 24)	1 (-17.5, 11)	-1.156	0.248[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 14. Between-Group Comparisons of Outcome Changes by Hypertension Subgroup

Variables	No				Yes			
	Intervention group (n=37)	Control group (n=43)	*t/Z*	*P*	Intervention group (n=46)	Control group (n=40)	*t/Z*	*P*
MoCA	0.05 ± 2.93	-0.53 ± 3.23	0.848	0.399[a]	0.54 ± 2.9	-0.75 ± 2.73	2.117	0.037[a]
AVLT-short delayed recall	0.62 ± 5.5	-0.07 ± 4.99	0.589	0.557[a]	0.59 ± 5.1	-0.58 ± 4.31	1.132	0.261[a]
AVLT-long delayed recall	0.19 ± 3.54	-0.79 ± 2.55	1.434	0.156[a]	-0.22 ± 2.33	-0.73 ± 2.16	1.043	0.300[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 2)	-0.078	0.938[b]	0 (-2, 1)	0 (-1, 1.75)	-0.053	0.958[b]
ROCFT-immediate recall	0.92 ± 8.66	-1.6 ± 7.88	1.364	0.177[a]	-0.11 ± 7.49	-3.85 ± 8.4	2.184	0.032[a]
ROCFT-long delayed recall	0.22 ± 7.44	-2.42 ± 8.34	1.480	0.143[a]	0.48 ± 8.1	-3.83 ± 7.99	2.472	0.015[a]
ROCFT-copy time	9 (-47.5, 65.5)	3 (-65, 57)	-0.526	0.599[b]	0 (-93.25, 98.5)	23.5 (-12.25, 88.75)	-1.598	0.110[b]
VFT	0.32 ± 3.65	-0.53 ± 3.37	1.094	0.277[a]	0.09 ± 3.95	0 ± 3.74	0.104	0.917[a]
BNT	1 (-2, 3)	0 (-2, 3)	-0.578	0.564[b]	1 (-2.25, 3)	-1 (-2, 1)	-1.296	0.195[b]
STT-A	0 (-9.5, 12)	1 (-14, 21)	-0.261	0.794[b]	0 (-12.75, 8)	7.5 (-4.5, 22)	-2.239	0.025[b]
STT-B	10 (-44, 33)	11 (-13, 48)	-1.235	0.217[b]	9 (-31.5, 28.5)	5.5 (-25.25, 45.75)	-0.511	0.609[b]
GDS-15	0 (-1, 1.5)	1 (-1, 2)	-1.025	0.306[b]	-1 (-2, 1)	-1 (-2, 1)	-0.699	0.484[b]
SAS	-1.25 (-4.25, 3.13)	1.25 (-3.75, 7.5)	-1.271	0.204[b]	0 (-4.06, 3.75)	1.25 (-7.19, 7.5)	-1.036	0.300[b]
UCLA loneliness scale	-2 (-9, 1.5)	0 (-7, 6)	-1.421	0.155[b]	-4.5 (-12, 0.5)	0 (-6, 4.75)	-2.377	0.017[b]
QoL-AD	3.89 ± 5.67	0.86 ± 6.28	2.251	0.027[a]	0.7 ± 7.03	5.15 ± 6.12	-3.112	0.003[a]
ADL	0 (0, 1)	0 (0, 1)	-0.699	0.485[b]	0 (0, 1)	0 (0, 1)	-0.193	0.847[b]
BBS	0 (-1.5, 1)	0 (-2, 1)	-0.343	0.732[b]	0 (-2, 0)	-1 (-2, 0)	-0.868	0.385[b]
HPLP-II	10.78 ± 33.22	10.58 ± 29.54	0.029	0.977[a]	17.5 ± 25.96	22.28 ± 29.86	-0.793	0.430[a]
SARHP	6 (-15, 17)	0 (-19, 11)	-1.380	0.168[b]	4 (-10, 24.25)	-1 (-21.75, 12.75)	-1.394	0.163[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 15. Between-Group Comparisons of Outcome Changes by Hyperlipidemia Subgroup

Variables	No				Yes			
	Intervention group (n=64)	Control group (n=70)	*t/Z*	*P*	Intervention group (n=19)	Control group (n=13)	*t/Z*	*P*
MoCA	0.16 ± 3.02	-0.49 ± 3.08	1.216	0.226[a]	0.89 ± 2.47	-1.46 ± 2.37	2.695	0.011[a]
AVLT-short delayed recall	0.39 ± 5.31	-0.39 ± 4.43	0.922	0.358[a]	1.32 ± 5.12	0.08 ± 5.89	0.632	0.532[a]
AVLT-long delayed recall	0.03 ± 3.2	-0.74 ± 2.3	1.619	0.108[a]	-0.26 ± 1.73	-0.85 ± 2.73	0.741	0.465[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 1.25)	-0.248	0.804[b]	0 (-2, 0)	-1 (-2.5, 2.5)	0.000	1.000[b]
ROCFT-immediate recall	0.05 ± 7.49	-2.71 ± 8.19	2.030	0.044[a]	1.37 ± 9.67	-2.54 ± 8.34	1.184	0.246[a]
ROCFT-long delayed recall	0.13 ± 7.98	-3.34 ± 8.05	2.502	0.014[a]	1.16 ± 7.16	-1.77 ± 8.94	1.027	0.313[a]
ROCFT-copy time	5 (-57, 80.25)	21 (-18.75, 70)	-0.927	0.354[b]	0 (-105, 100)	-2 (-97.5, 68.5)	-0.211	0.833[b]
VFT	0.25 ± 3.64	-0.1 ± 3.38	0.577	0.565[a]	0 ± 4.4	-1.23 ± 4.36	0.780	0.441[a]
BNT	1 (-2.75, 3)	0 (-2, 2)	-0.904	0.366[b]	1 (-2, 4)	-1 (-3.5, 3)	-0.674	0.500[b]
STT-A	0 (-10, 11)	5 (-10.25, 20.25)	-1.114	0.265[b]	-2 (-14, 7)	9 (-4.5, 25)	-1.728	0.084[b]
STT-B	7 (-35.75, 29.5)	11 (-15.5, 48.75)	-1.613	0.107[b]	10 (-43, 38)	-1 (-45.5, 44)	-0.403	0.687[b]
GDS-15	0 (-1.75, 1)	0 (-1, 1)	-0.716	0.474[b]	-1 (-4, 1)	0 (-1.5, 2)	-1.657	0.098[b]
SAS	0 (-3.44, 3.75)	1.88 (-5, 7.5)	-1.113	0.266[b]	-2.5 (-7.5, 3.75)	1.25 (-1.88, 6.25)	-1.384	0.166[b]
UCLA loneliness scale	-3.5 (-10, 0)	0.5 (-6, 7)	-3.032	0.002[b]	0 (-11, 6)	0 (-9, 5)	-0.096	0.923[b]
QoL-AD	2.42 ± 6.93	3.23 ± 6.73	-0.683	0.496[a]	1.11 ± 5.48	1.31 ± 5.25	-0.104	0.918[a]
ADL	0 (0, 1)	0 (0, 1)	-0.226	0.821[b]	0 (0, 1)	1 (0, 1)	-0.063	0.950[b]
BBS	0 (-1.75, 0)	-0.5 (-2, 0)	-0.914	0.361[b]	0 (-3, 0)	1 (-2, 2)	-1.655	0.098[b]
HPLP-II	14.77 ± 29.45	17.76 ± 30	-0.582	0.562[a]	13.63 ± 30.14	7.92 ± 30.45	0.524	0.604[a]
SARHP	4 (-13.75, 21.75)	0 (-19.5, 15.25)	-1.094	0.274[b]	9 (-9, 33)	-4 (-18, 2)	-2.073	0.038[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 16. Between-Group Comparisons of Outcome Changes by Chronic Heart Disease Subgroup

Variables	No				Yes			
	Intervention group (n=64)	Control group (n=70)	*t/Z*	*P*	Intervention group (n=19)	Control group (n=13)	*t/Z*	*P*
MoCA	0.38 ± 2.95	-0.89 ± 2.94	2.528	0.013[a]	0.07 ± 2.81	0.69 ± 2.98	-0.557	0.583[a]
AVLT-short delayed recall	0.48 ± 5.4	-0.56 ± 4.77	1.198	0.233[a]	1.21 ± 4.56	1 ± 3.85	0.131	0.897[a]
AVLT-long delayed recall	0.1 ± 2.99	-0.73 ± 2.3	1.839	0.068[a]	-0.71 ± 2.55	-0.92 ± 2.75	0.204	0.840[a]
AVLT-recognition recall	0 (-2, 1)	0 (-1, 1)	-0.175	0.861[b]	0.5 (-1, 1.25)	1 (-1, 4.5)	-0.515	0.606[b]
ROCFT-immediate recall	0.45 ± 8.23	-3.44 ± 7.61	2.896	0.004[a]	-0.14 ± 6.98	1.38 ± 10.07	-0.461	0.649[a]
ROCFT-long delayed recall	0.72 ± 7.29	-3.8 ± 7.85	3.521	<0.001[a]	-1.43 ± 9.93	0.69 ± 9.06	-0.578	0.568[a]
ROCFT-copy time	1 (-71.5, 71.5)	21 (-18.75, 70.25)	-1.281	0.200[b]	14.5 (-33.25, 101.75)	-1 (-63.5, 49.5)	-1.068	0.286[b]
VFT	0.59 ± 3.58	-0.09 ± 3.51	1.130	0.261[a]	-1.79 ± 4.35	-1.31 ± 3.66	-0.308	0.761[a]
BNT	1 (-2, 3)	0 (-2, 2)	-1.316	0.188[b]	0.5 (-2.25, 3)	-1 (-2.5, 2.5)	-0.073	0.942[b]
STT-A	0 (-11, 9)	6 (-10.25, 20.25)	-1.671	0.095[b]	0.5 (-8.5, 18.25)	1 (-5.5, 25)	-0.657	0.511[b]
STT-B	10 (-37.5, 30.5)	7.5 (-20.25, 46.5)	-0.935	0.350[b]	7 (-57.25, 36.5)	23 (-15.5, 48.5)	-0.971	0.332[b]
GDS-15	-1 (-2, 1)	0 (-1.25, 1.25)	-1.105	0.269[b]	0 (-1.25, 1)	1 (-0.5, 1.5)	-1.061	0.289[b]
SAS	0 (-3.75, 3.75)	0.63 (-5, 6.56)	-0.787	0.431[b]	-0.88 (-11.88, 3.44)	7.5 (1.25, 9.38)	-2.068	0.039[b]
UCLA loneliness scale	-2 (-9, 0)	0 (-6.25, 6)	-2.138	0.033[b]	-5.5 (-16.5, 3.75)	3 (-1, 6.5)	-1.457	0.145[b]
QoL-AD	2 ± 6.67	3.11 ± 6.55	-0.993	0.322[a]	2.71 ± 6.52	1.92 ± 6.6	0.313	0.757[a]
ADL	0 (0, 1)	0 (0, 1)	-0.075	0.941[b]	0 (0, 1)	0 (0, 1)	-0.557	0.578[b]
BBS	0 (-2, 0)	-1 (-2, 0)	-0.990	0.322[b]	-0.5 (-2, 0)	1 (-2, 2)	-1.739	0.082[b]
HPLP-II	15.46 ± 30.78	17.4 ± 28.85	-0.383	0.703[a]	9.79 ± 21.87	9.85 ± 36.75	-0.005	0.996[a]
SARHP	6 (-13.5, 24)	1 (-17.25, 15.25)	-1.201	0.230[b]	4 (-7.25, 24.25)	-15 (-34.5, -0.5)	-2.233	0.026[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 17. Between-Group Comparisons of Outcome Changes by Thyroid Diseases Subgroup

Variables	No				Yes			
	Intervention group (n=79)	Control group (n=75)	*t/Z*	*P*	Intervention group (n=4)	Control group (n=8)	*t/Z*	*P*
MoCA	0.28 ± 2.86	-0.51 ± 2.97	1.673	0.096[a]	1.25 ± 4.27	-1.88 ± 3.04	1.475	0.171[a]
AVLT-short delayed recall	0.73 ± 4.98	-0.19 ± 4.67	1.182	0.239[a]	-2 ± 9.97	-1.5 ± 4.57	-0.123	0.905[a]
AVLT-long delayed recall	0.04 ± 2.9	-0.67 ± 2.33	1.659	0.099[a]	-1.5 ± 3.42	-1.63 ± 2.62	0.071	0.945[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 2)	-0.265	0.791[b]	-2 (-4.5, 2)	0.5 (-0.75, 1)	-1.120	0.263[b]
ROCFT-immediate recall	0.27 ± 8.16	-2.27 ± 8.27	1.912	0.058[a]	2 ± 3.56	-6.63 ± 6.16	2.555	0.029[a]
ROCFT-long delayed recall	0.41 ± 7.81	-2.68 ± 8.11	2.406	0.017[a]	-0.5 ± 7.94	-7 ± 8.09	1.320	0.216[a]
ROCFT-copy time	6 (-57, 85)	21 (-35, 70)	-0.600	0.548[b]	-63 (-190.75, 16)	3.5 (-36.25, 25.75)	-1.019	0.308[b]
VFT	0.25 ± 3.86	0.05 ± 3.33	0.343	0.732[a]	-1 ± 2.16	-3.38 ± 4.17	1.052	0.317[a]
BNT	1 (-2, 3)	0 (-2, 2)	-0.902	0.367[b]	0.5 (-4.25, 4.5)	-2 (-2.75, -0.25)	-0.693	0.488[b]
STT-A	0 (-10, 11)	4 (-10, 21)	-0.942	0.346[b]	-17.5 (-33, -8.75)	20 (3.75, 25)	-2.646	0.008[b]
STT-B	8 (-38, 31)	8 (-21, 48)	-1.148	0.251[b]	14 (-34.25, 26.25)	27 (-16.5, 52.5)	-0.510	0.610[b]
GDS-15	0 (-2, 1)	0 (-1, 2)	-1.306	0.192[b]	-1 (-3.25, -0.25)	-0.5 (-1.75, 1)	-0.869	0.385[b]
SAS	0 (-3.75, 3.75)	1.25 (-5, 7.5)	-1.435	0.151[b]	0 (-9.06, 3.44)	0.63 (0, 4.38)	-0.600	0.549[b]
UCLA loneliness scale	-4 (-11, 2)	0 (-6, 6)	-2.613	0.009[b]	-0.5 (-3.25, 0)	0 (-10, 6)	-0.346	0.729[b]
QoL-AD	1.99 ± 6.71	2.69 ± 6.51	-0.662	0.509[a]	4.75 ± 4.03	5.13 ± 6.79	-0.100	0.922[a]
ADL	0 (0, 1)	0 (0, 1)	-0.423	0.673[b]	0 (0, 0)	0 (0, 1)	-0.816	0.414[b]
BBS	0 (-2, 0)	0 (-2, 1)	-0.181	0.856[b]	0 (-2.25, 5.25)	-1 (-3.5, 0)	-0.882	0.378[b]
HPLP-II	14.66 ± 29.28	15.96 ± 30.42	-0.271	0.787[a]	11.5 ± 37.01	18.63 ± 28.62	-0.371	0.718[a]
SARHP	5 (-9, 24)	0 (-19, 12)	-1.965	0.049[b]	-9.5 (-19, 33.75)	-1 (-18.25, 18)	-0.340	0.734[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 18. Between-Group Comparisons of Outcome Changes by Suffer from Insomnia Subgroup

Variables	No				Yes			
	Intervention group (n=60)	Control group (n=78)	*t/Z*	*P*	Intervention group (n=23)	Control group (n=5)	*t/Z*	*P*
MoCA	0.2 ± 3.13	-0.56 ± 2.93	1.474	0.143[a]	0.65 ± 2.27	-1.8 ± 3.96	1.910	0.067[a]
AVLT-short delayed recall	0.83 ± 5.12	-0.4 ± 4.71	1.465	0.145[a]	0 ± 5.66	1 ± 3.67	-0.375	0.710[a]
AVLT-long delayed recall	-0.02 ± 2.9	-0.82 ± 2.39	1.784	0.077[a]	-0.09 ± 3.03	0.2 ± 1.64	-0.203	0.840[a]
AVLT-recognition recall	0 (-2, 1)	0 (-1, 1)	-0.093	0.926[b]	0 (-1, 1)	2 (0.5, 2.5)	-1.432	0.152[b]
ROCFT-immediate recall	0.02 ± 8.6	-2.96 ± 8.25	2.064	0.041[a]	1.22 ± 6.27	1.6 ± 5.46	-0.126	0.901[a]
ROCFT-long delayed recall	0.2 ± 8.13	-3.46 ± 8.22	2.607	0.010[a]	0.78 ± 6.88	2.6 ± 4.56	-0.560	0.580[a]
ROCFT-copy time	0 (-60, 84.5)	20 (-35.5, 70)	-0.685	0.493[b]	6 (-92, 60)	14 (-39, 61)	-0.210	0.834[b]
VFT	0.25 ± 3.81	-0.29 ± 3.56	0.864	0.389[a]	0.04 ± 3.87	0 ± 3.54	0.023	0.982[a]
BNT	0 (-3, 3)	0 (-2, 2)	-0.069	0.945[b]	2 (1, 4)	2 (-3.5, 3)	-0.907	0.365[b]
STT-A	0 (-10, 8)	4.5 (-10, 21.25)	-1.590	0.112[b]	-1 (-15, 17)	20 (2.5, 31)	-1.290	0.197[b]
STT-B	10 (-37.75, 30.75)	7.5 (-22.5, 44.25)	-0.752	0.452[b]	4 (-43, 30)	57 (35.5, 67.5)	-2.429	0.015[b]
GDS-15	0 (-1, 1)	0 (-1.25, 2)	-0.753	0.452[b]	-1 (-4, 0)	0 (-1, 1)	-0.977	0.328[b]
SAS	0 (-3.75, 3.44)	1.25 (-5, 7.5)	-1.035	0.301[b]	-2.5 (-6.25, 3.75)	8.75 (3.75, 24.38)	-2.407	0.016[b]
UCLA loneliness scale	-1.5 (-9.75, 2)	0 (-6, 6)	-2.230	0.026[b]	-4 (-11, 0)	4 (-25.5, 13.5)	-0.391	0.696[b]
QoL-AD	1.53 ± 7.32	3.22 ± 6.43	-1.437	0.153[a]	3.65 ± 4.01	-1.6 ± 7.23	2.289	0.030[a]
ADL	0 (0, 1)	0 (0, 1)	-0.368	0.713[b]	0 (0, 1)	0 (-0.5, 1)	-0.891	0.373[b]
BBS	0 (-1.75, 0)	0 (-2, 1)	-0.563	0.574[b]	-1 (-2, 0)	-1 (-1.5, 0)	-0.094	0.925[b]
HPLP-II	19.17 ± 30.56	16.56 ± 30.61	0.496	0.621[a]	2.35 ± 22.56	10.8 ± 22.26	-0.761	0.454[a]
SARHP	5 (-16.75, 24)	-1 (-21, 12.25)	-1.426	0.154[b]	5 (-2, 24)	3 (-1, 23.5)	-0.330	0.741[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 19. Between-Group Comparisons of Outcome Changes by Depression Subgroup

Variables	No				Yes			
	Intervention group (n=64)	Control group (n=64)	*t/Z*	*P*	Intervention group (n=19)	Control group (n=19)	*t/Z*	*P*
MoCA	0.27 ± 3.11	-0.64 ± 2.92	1.699	0.092[a]	0.53 ± 2.17	-0.63 ± 3.27	1.286	0.207[a]
AVLT-short delayed recall	0.53 ± 5.05	-0.31 ± 4.47	1.001	0.319[a]	0.84 ± 6.03	-0.32 ± 5.35	0.626	0.535[a]
AVLT-long delayed recall	0.08 ± 2.97	-0.59 ± 2.33	1.424	0.157[a]	-0.42 ± 2.8	-1.32 ± 2.4	1.058	0.297[a]
AVLT-recognition recall	0 (-2, 1)	0 (-1, 1.75)	-0.118	0.906[b]	0 (0, 1)	0 (-1, 2)	-0.208	0.835[b]
ROCFT-immediate recall	0.06 ± 7.18	-1.89 ± 8.02	1.452	0.149[a]	1.32 ± 10.48	-5.37 ± 8.29	2.181	0.036[a]
ROCFT-long delayed recall	0.06 ± 7.67	-2.42 ± 8.07	1.785	0.077[a]	1.37 ± 8.23	-5.37 ± 8.24	2.522	0.016[a]
ROCFT-copy time	2.5 (-54, 63)	16.5 (-32.5, 70)	-0.932	0.351[b]	14 (-94, 100)	23 (-35, 67)	-0.015	0.988[b]
VFT	0.39 ± 3.93	-0.23 ± 3.2	0.987	0.326[a]	-0.47 ± 3.34	-0.42 ± 4.62	-0.040	0.968[a]
BNT	1 (-2, 3)	-0.5 (-2, 2)	-1.075	0.283[b]	1 (-2, 3)	0 (-2, 3)	-0.484	0.628[b]
STT-A	0.5 (-10.75, 10)	3.5 (-11, 24.25)	-1.177	0.239[b]	-1 (-11, 15)	6 (-1, 13)	-1.432	0.152[b]
STT-B	10 (-29, 34)	9.5 (-20.75, 47.5)	-0.739	0.460[b]	-16 (-51, 19)	11 (-19, 51)	-1.387	0.165[b]
GDS-15	0 (-1, 1)	0 (-1, 2)	-0.307	0.759[b]	-4 (-6, -1)	-1 (-2, 1)	-2.778	0.005[b]
SAS	0 (-4.5, 3.75)	1.25 (-3.44, 7.5)	-1.456	0.145[b]	-1.75 (-3.75, 2.5)	2.5 (-10, 8.75)	-0.511	0.609[b]
UCLA loneliness scale	-1.5 (-8, 2)	0 (-6, 6)	-2.085	0.037[b]	-7 (-16, 0)	1 (-7, 6)	-1.651	0.099[b]
QoL-AD	2.61 ± 6.64	2.13 ± 6.53	0.416	0.678[a]	0.47 ± 6.43	5.63 ± 5.94	-2.568	0.015[a]
ADL	0 (0, 1)	0 (0, 1)	-0.103	0.918[b]	0 (0, 1)	0 (0, 1)	-0.447	0.655[b]
BBS	0 (-2, 0)	0 (-2, 0.75)	-0.182	0.855[b]	0 (-2, 1)	-1 (-2, 1)	-0.576	0.565[b]
HPLP-II	14.19 ± 31.07	12.81 ± 29.27	0.258	0.797[a]	15.58 ± 23.73	27.68 ± 30.78	-1.358	0.183[a]
SARHP	4.5 (-15.25, 24)	-0.5 (-18, 10)	-1.652	0.099[b]	7 (-4, 27)	0 (-24, 23)	-0.745	0.456[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 20. Between-Group Comparisons of Outcome Changes by Family History of Dementia Subgroup

Variables	No				Yes			
	Intervention group (n=76)	Control group (n=69)	*t/Z*	*P*	Intervention group (n=7)	Control group (n=14)	*t/Z*	*P*
MoCA	0.28 ± 2.85	-0.61 ± 3.13	1.781	0.077[a]	0.86 ± 3.67	-0.79 ± 2.22	1.284	0.215[a]
AVLT-short delayed recall	0.68 ± 5.23	-0.49 ± 4.58	1.435	0.153[a]	-0.29 ± 5.82	0.57 ± 5.08	-0.348	0.732[a]
AVLT-long delayed recall	0.01 ± 2.91	-0.75 ± 2.33	1.742	0.084[a]	-0.57 ± 3.26	-0.79 ± 2.58	0.165	0.871[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 1.5)	-0.148	0.882[b]	0 (-3, 2)	0 (-2, 3.5)	-0.565	0.572[b]
ROCFT-immediate recall	0.32 ± 7.95	-2.96 ± 7.82	2.495	0.014[a]	0.71 ± 9.23	-1.36 ± 9.9	0.461	0.650[a]
ROCFT-long delayed recall	0.57 ± 7.44	-2.86 ± 7.47	2.761	0.007[a]	-1.86 ± 11.28	-4.29 ± 11.22	0.467	0.646[a]
ROCFT-copy time	0 (-74.25, 68.25)	14 (-41.5, 67.5)	-0.794	0.427[b]	83 (42, 124)	33 (0.75, 143.25)	-0.784	0.433[b]
VFT	-0.12 ± 3.65	-0.36 ± 3.48	0.411	0.682[a]	3.57 ± 4.04	0.14 ± 3.94	1.866	0.078[a]
BNT	1 (-1.75, 3)	0 (-2, 2)	-1.598	0.110[b]	-2 (-3, -2)	-1 (-2.25, 3)	-1.225	0.221[b]
STT-A	0 (-10, 9.5)	6 (-10, 22)	-1.635	0.102[b]	1 (-19, 27)	2.5 (-6.25, 21.25)	-0.635	0.525[b]
STT-B	6 (-38.75, 30)	11 (-20.5, 45.5)	-1.229	0.219[b]	18 (-15, 61)	15.5 (-13.25, 56.75)	-0.075	0.941[b]
GDS-15	0 (-1, 1)	0 (-1, 2)	-1.125	0.261[b]	-2 (-4, -1)	-0.5 (-2, 1)	-1.697	0.090[b]
SAS	0 (-3.5, 3.75)	1.25 (-5, 7.5)	-1.731	0.084[b]	-5 (-11.25, 11.25)	0.63 (-9.06, 5.94)	-0.374	0.709[b]
UCLA loneliness scale	-2.5 (-10.75, 0)	0 (-6.5, 6)	-2.523	0.012[b]	-8 (-9, 3)	1 (-6, 7.75)	-0.823	0.411[b]
QoL-AD	2.26 ± 6.86	2.22 ± 6.51	0.041	0.967[a]	0.57 ± 2.57	6.43 ± 5.61	-2.602	0.017[a]
ADL	0 (0, 1)	0 (0, 1)	-0.109	0.913[a]	0 (0, 1)	0 (0, 1)	-0.650	0.516[b]
BBS	0 (-2, 0)	-1 (-2, 1)	-0.635	0.525[a]	-1 (-2, 1)	0 (-0.5, 1.5)	-1.000	0.318[b]
HPLP-II	16.07 ± 28.33	16.17 ± 31.09	-0.022	0.983[a]	-2.43 ± 37.87	16.43 ± 25.67	-1.355	0.191[a]
SARHP	4 (-13, 21.75)	0 (-16, 11.5)	-1.309	0.191[b]	25 (1, 31)	-17 (-34.75, 16.75)	-1.791	0.073[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 21. Between-Group Comparisons of Outcome Changes by History of Falls Subgroup

Variables	No				Yes			
	Intervention group (n=68)	Control group (n=68)	*t/Z*	*P*	Intervention group (n=15)	Control group (n=15)	*t/Z*	*P*
MoCA	0.31 ± 2.91	-0.78 ± 3.04	2.135	0.035[a]	0.4 ± 3.02	0 ± 2.75	0.379	0.707[a]
AVLT-short delayed recall	0.69 ± 5.26	-0.4 ± 4.58	1.286	0.201[a]	0.2 ± 5.37	0.07 ± 5.09	0.070	0.945[a]
AVLT-long delayed recall	0 ± 2.88	-0.51 ± 2.32	1.149	0.253[a]	-0.2 ± 3.21	-1.87 ± 2.26	1.643	0.112[a]
AVLT-recognition recall	0 (-1, 1)	0 (-1, 2)	-0.522	0.602[b]	0 (-2, 3)	0 (-2, 0)	-0.802	0.423[b]
ROCFT-immediate recall	-0.01 ± 8.34	-2.46 ± 8.52	1.688	0.094[a]	2 ± 6.16	-3.73 ± 6.45	2.488	0.019[a]
ROCFT-long delayed recall	0.66 ± 7.7	-2.63 ± 8.17	2.419	0.017[a]	-1 ± 8.18	-5.2 ± 8.02	1.420	0.167[a]
ROCFT-copy time	2.5 (-60, 80.25)	20 (-35.5, 70)	-0.738	0.461[b]	13 (-66, 85)	7 (-35, 69)	-0.062	0.950[b]
VFT	-0.07 ± 3.94	-0.32 ± 3.61	0.386	0.700[a]	1.4 ± 2.9	-0.07 ± 3.33	1.287	0.208[a]
BNT	1 (-2, 3)	0 (-2, 2.75)	-0.891	0.373[b]	0 (-5, 3)	-1 (-4, -1)	-0.648	0.517[b]
STT-A	-0.5 (-10, 9.5)	4.5 (-10, 20.75)	-1.691	0.091[b]	1 (-16, 27)	8 (-7, 22)	-0.311	0.756[b]
STT-B	6.5 (-35.75, 30.75)	11 (-18.5, 47.5)	-1.210	0.226[b]	10 (-52, 30)	-1 (-35, 49)	-0.539	0.590[b]
GDS-15	-1 (-2, 1)	0 (-1, 1)	-1.917	0.055[b]	0 (-1, 1)	-1 (-2, 2)	-0.460	0.646[b]
SAS	-1.25 (-4.94, 3.75)	1.25 (-5, 7.5)	-1.728	0.084[b]	0 (-2.5, 2.5)	0 (-8.75, 5)	-0.208	0.835[b]
UCLA loneliness scale	-5 (-11, 0)	0 (-6, 6)	-2.920	0.003[b]	0 (-3, 3)	1 (-7, 5)	-0.083	0.934[b]
QoL-AD	1.49 ± 6.8	2.75 ± 6.61	-1.100	0.273[a]	5 ± 4.88	3.73 ± 6.34	0.613	0.545[a]
ADL	0 (0, 1)	0 (0, 1)	-0.069	0.945[b]	0 (0, 1)	0 (0, 1)	-0.891	0.373[b]
BBS	0 (-1.75, 0)	0 (-2, 0.75)	-0.670	0.503[b]	-1 (-2, 0)	0 (-2, 2)	-0.925	0.355[b]
HPLP-II	15.5 ± 28.15	13.93 ± 28.08	0.326	0.745[a]	10 ± 35.38	26.6 ± 37.28	-1.251	0.221[a]
SARHP	7.5 (-4.75, 24.75)	0 (-18, 11.75)	-2.573	0.010[b]	-16 (-28, 4)	-11 (-30, 19)	-0.519	0.604[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

IV. MCI subtypes

Table 22. Between-Group Comparisons of Outcome Changes by MCI subtypes

Variables	Non-amnestic MCI				Amnestic MCI			
	Intervention group (n = 72)	Control group (n = 68)	*t/Z*	*P*	Intervention group (n = 11)	Control group (n = 15)	*t/Z*	*P*
MoCA	0.49 ± 2.85	-0.69 ± 2.9	2.420	0.017[a]	-0.73 ± 3.2	-0.4 ± 3.44	-0.247	0.807[a]
AVLT-short delayed recall	0.32 ± 5.3	-0.76 ± 4.09	1.350	0.179[a]	2.45 ± 4.76	1.73 ± 6.41	0.314	0.756[a]
AVLT-long delayed recall	-0.38 ± 2.88	-1.29 ± 2.19	2.120	0.036[a]	2.18 ± 2.23	1.67 ± 1.4	0.725	0.476[a]
AVLT-recognition recall	0 (-1.75, 1)	0 (-1, 1)	-0.032	0.975[b]	1 (0, 3)	0 (-1, 4)	-0.288	0.773[b]
ROCFT-immediate recall	0.67 ± 8.2	-3.59 ± 7.83	3.138	0.002[a]	-1.73 ± 6.48	1.4 ± 8.68	-1.005	0.325[a]
ROCFT-long delayed recall	0.76 ± 7.91	-4.38 ± 7.64	3.912	<0.001[a]	-2.27 ± 6.47	2.73 ± 8.11	-1.688	0.104[a]
ROCFT-copy time	9.5 (-57, 84.5)	23.5 (-20.5, 70)	-0.678	0.498[b]	-25 (-121, 23)	-7 (-65, 21)	-0.753	0.452[b]
VFT	0.15 ± 3.57	-0.31 ± 3.64	0.757	0.451[a]	0.45 ± 5.26	-0.13 ± 3.16	0.356	0.725[a]
BNT	1 (-2, 3)	-1 (-2, 2)	-1.667	0.095[b]	0 (-3, 4)	1 (0, 3)	-0.653	0.514[b]
STT-A	0 (-11, 10)	6 (-8, 20.75)	-2.029	0.042[b]	1 (-9, 27)	-1 (-14, 32)	-0.208	0.835[b]
STT-B	6 (-42, 29.5)	11 (-15, 48)	-1.851	0.064[b]	13 (-22, 38)	-12 (-49, 40)	-0.779	0.436[b]
GDS-15	0 (-1, 1)	0 (-1, 2)	-1.141	0.254[b]	-1 (-4, 0)	0 (-2, 1)	-1.155	0.248[b]
SAS	0 (-2.69, 3.75)	2.5 (-3.44, 7.5)	-1.637	0.102[b]	-3.75 (-11, -1.25)	-1.25 (-5, 5)	-0.652	0.515[b]
UCLA loneliness scale	-2.5 (-10.75, 0)	0 (-7, 6)	-2.021	0.043[b]	-4 (-8, 3)	3 (-3, 6)	-1.925	0.054[b]
QoL-AD	1.94 ± 6.88	2.82 ± 6.53	-0.774	0.440[a]	3.27 ± 4.54	3.4 ± 6.77	-0.054	0.957[a]
ADL	0 (0, 1)	0 (0, 1)	-0.526	0.599[b]	0 (0, 1)	0 (0, 1)	-0.342	0.733[b]
BBS	0 (-1.75, 0)	0 (-2, 0)	-0.618	0.537[b]	-1 (-3, 0)	0 (-2, 2)	-0.576	0.564[b]
HPLP-II	14.11 ± 29.88	16.09 ± 28.77	-0.398	0.691[a]	17.09 ± 27.46	16.8 ± 36.65	0.022	0.983[a]
SARHP	5 (-7.75, 23.5)	0 (-16.75, 11)	-1.737	0.082[b]	0 (-20, 42)	-7 (-51, 29)	-1.064	0.287[b]

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).
a denotes two-sample independent t-test, b denotes Mann-Whitney U test.
Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Appendix 6. Subgroup Analysis of Intervention Effects Based on Adherence Levels

Table 1 Comparison of Intervention Effects by Overall Adherence Levels Subgroup

Variables	Low-adherence group (n = 19)	High-adherence group (n = 64)	*t/Z*	*P*	*d/r*
MoCA	0.16 ± 3.69	0.38 ± 2.67	0.284	0.777[a]	0.074
AVLT-short delayed recall	1 ± 5.5	0.48 ± 5.22	-0.374	0.710[a]	0.098
AVLT-long delayed recall	-0.16 ± 3.25	0 ± 2.84	0.206	0.837[a]	0.054
AVLT-recognition recall	-1 (-2, 2)	0 (-1, 1)	-1.482	0.138[b]	0.222
ROCFT-immediate recall	-1.79 ± 6.85	0.98 ± 8.25	1.334	0.186[a]	0.348
ROCFT-long delayed recall	-0.26 ± 6.09	0.55 ± 8.23	0.397	0.692[a]	0.104
ROCFT-copy time	6 (-32, 72)	2.5 (-86.75, 89.75)	-0.271	0.786[b]	0.041
VFT	0.58 ± 3.61	0.08 ± 3.88	-0.502	0.617[a]	0.131
BNT	1 (-3, 3)	1 (-2, 3)	-0.495	0.621[b]	0.075
STT-A	-1 (-10, 8)	0 (-11, 11.75)	-0.428	0.668[b]	0.065
STT-B	10 (-29, 35)	6(-42, 29.5)	-0.618	0.537[b]	0.094
GDS-15	0 (-1, 2)	-1 (-2, 1)	-1.532	0.126[b]	0.229
SAS	0 (-2.5, 3.75)	-0.88 (-4.5, 3.75)	-0.402	0.688[b]	0.061
UCLA loneliness scale	-5 (-16, 3)	-2.5 (-9.75, 0)	-0.500	0.617[b]	0.076
QoL-AD	2.68 ± 8.37	1.95 ± 6.07	-0.421	0.675[a]	0.110
ADL	0 (0, 0)	0 (0, 1)	-1.007	0.314[b]	0.131
BBS	0 (-2, 0)	0 (-2, 0)	-0.130	0.896[b]	0.019
HPLP-II	21.95 ± 39.25	12.3 ± 25.79	-1.260	0.211[a]	0.329
SARHP	6 (-6, 30)	4.5 (-13, 24)	-0.461	0.645[b]	0.070

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).

a denotes two-sample independent t-test, b denotes Mann-Whitney U test.

Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 2. Between-Group Comparisons of Outcome Changes by Daily Health Lifestyle Record Subgroup

Variables	Low-participation group (n=18)	High-participation group (n=65)	*t/Z*	*P*	*d/r*
MoCA	0.44 ± 2.97	0.29 ± 2.91	0.195	0.846[a]	0.052
AVLT-short delayed recall	-1.22 ± 5.81	1.11 ± 5.02	-1.684	0.096[a]	0.449
AVLT-long delayed recall	-1.39 ± 2.89	0.34 ± 2.84	-2.277	0.025[a]	0.607
AVLT-recognition recall	0.5 (-1, 2)	-2 (0, 0)	-1.046	0.295[b]	0.160
ROCFT-immediate recall	1.06 ± 9.3	0.15 ± 7.67	0.421	0.675[a]	0.112
ROCFT-long delayed recall	0.83 ± 7.49	0.23 ± 7.9	0.290	0.773[a]	0.077
ROCFT-copy time	-10.5 (-72.5, 49.5)	-59 (0, 13)	-0.840	0.401[b]	0.130
VFT	0.83 ± 3.13	0.02 ± 3.97	0.806	0.423[a]	0.215
BNT	0.5 (-2.25, 2.25)	-2 (0, 1)	-0.577	0.564[b]	0.089
STT-A	-0.5 (-7.75, 12.25)	-11.5 (0, 0)	-0.862	0.389[b]	0.133
STT-B	14.5 (-6.25, 38.25)	-43.5 (0, -1)	-1.387	0.165[b]	0.215
GDS-15	-1 (-4.25, 0.25)	-1 (0, 0)	-1.533	0.125[b]	0.234
SAS	-0.88 (-5.31, 2.5)	-3.75 (0, 0)	-0.487	0.626[b]	0.075
UCLA loneliness scale	-7.5 (-16, 5.25)	-8.5 (0, -2)	-0.703	0.482[b]	0.109
QoL-AD	3.22 ± 6.96	1.82 ± 6.54	0.797	0.428[a]	0.212
ADL	0 (0, 0)	0 (0, 0)	-1.227	0.220[b]	0.162
BBS	0 (-1.25, 0.25)	-2 (0, 0)	-0.491	0.623[b]	0.073
HPLP-II	12.22 ± 33.37	15.14 ± 28.49	-0.370	0.712[a]	0.099
SARHP	9 (-4, 20.5)	-13.5 (0, 4)	-0.442	0.658[b]	0.068

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).

a denotes two-sample independent t-test, b denotes Mann-Whitney U test.

Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 3. Between-Group Comparisons of Outcome Measures by Health Education Subgroup

Variables	Low-participation group (n=24)	High-participation group (n=59)	*t/Z*	*P*	*d/r*
MoCA	-0.21±2.77	0.54±2.96	-1.067	0.289[a]	0.258
AVLT-short delayed recall	0.25±5.29	0.75±5.28	-0.388	0.699[a]	0.094
AVLT-long delayed recall	-0.46±2.48	0.14±3.08	-0.839	0.404[a]	0.203
AVLT-recognition recall	0 (-2, 1)	0 (-1, 1)	-0.661	0.509[b]	0.092
ROCFT-immediate recall	-2.00±6.40	1.31±8.43	-1.727	0.088[a]	0.418
ROCFT-long delayed recall	0.33±6.89	0.37±8.15	-0.021	0.983[a]	0.005
ROCFT-copy time	-40 (-88.25, 8.25)	23 (-41, 92)	-2.165	0.030[b]	0.304
VFT	0.04±2.80	0.25±4.16	-0.230	0.819[a]	0.056
BNT	0.5 (-2.75, 2)	1 (-2, 3)	-1.079	0.281[b]	0.151
STT-A	0.5 (-5, 6.75)	-2 (-12, 11)	-0.734	0.463[b]	0.103
STT-B	10.5 (-26.5, 38)	8 (-39, 24)	-0.980	0.327[b]	0.138
GDS-15	-1 (-2, 1)	0 (-1, 1)	-0.438	0.662[b]	0.061
SAS	-0.63 (-3.75, 4.69)	0 (-5, 3.75)	-0.423	0.673[b]	0.059
UCLA loneliness scale	-7.5 (-16, -1)	-1 (-10, 2)	-1.833	0.067[b]	0.257
QoL-AD	2.46±7.83	1.98±6.12	0.295	0.769[a]	0.071
ADL	0 (0, 0)	0 (0, 1)	-2.219	0.027[b]	0.267
BBS	0 (0, 0)	0 (-2, 0)	-1.696	0.090[b]	0.228
HPLP-II	13.33±27.89	14.98±30.25	-0.230	0.818[a]	0.056
SARHP	6 (-5.5, 23.25)	4 (-16, 24)	-0.462	0.644[b]	0.065

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).

a denotes two-sample independent t-test, b denotes Mann-Whitney U test.

Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 4. Between-Group Comparisons of Outcome Changes by Cognitive Stimulation Subgroup

Variables	Low-participation group (n=33)	High-participation group (n=50)	*t/Z*	*P*	*d/r*
MoCA	0.18 ± 2.59	0.42 ± 3.12	-0.363	0.718[a]	0.081
AVLT-short delayed recall	0.15 ± 5.54	0.9 ± 5.09	-0.633	0.528[a]	0.142
AVLT-long delayed recall	-0.21 ± 2.97	0.08 ± 2.91	-0.444	0.658[a]	0.100
AVLT-recognition recall	0 (-1.5, 1)	0 (-1.25, 1)	-0.612	0.540[b]	0.079
ROCFT-immediate recall	-1.45 ± 8.09	1.54 ± 7.79	-1.688	0.095[a]	0.379
ROCFT-long delayed recall	0.15 ± 6.38	0.5 ± 8.62	-0.199	0.843[a]	0.045
ROCFT-copy time	-8 (-59, 38.5)	19 (-72, 98.5)	-1.173	0.241[b]	0.153
VFT	0.24 ± 3.74	0.16 ± 3.88	0.096	0.924[a]	0.022
BNT	0 (-2, 2)	1 (-2.25, 4)	-1.009	0.313[b]	0.131
STT-A	1 (-7.5, 10.5)	-2 (-14.25, 10.25)	-1.233	0.217[b]	0.161
STT-B	10 (-20.5, 36.5)	3.5 (-43.25, 25)	-1.08	0.280[b]	0.141
GDS-15	-1 (-2, 0.5)	0 (-1.25, 1)	-0.655	0.512[b]	0.084
SAS	-1.25 (-4.25, 3.75)	0 (-4.06, 3.75)	-0.242	0.808[b]	0.032
UCLA loneliness scale	-6 (-16, -0.5)	-0.5 (-8.25, 2.25)	-1.922	0.055[b]	0.250
QoL-AD	1.39 ± 7.57	2.6 ± 5.94	-0.811	0.420[a]	0.182
ADL	0 (0, 0)	0 (0, 1)	-2.860	0.004[b]	0.319
BBS	0 (-0.5, 0)	0 (-3, 0)	-1.946	0.052[b]	0.242
HPLP-II	17.42 ± 29.06	12.58 ± 29.8	0.732	0.466[a]	0.164
SARHP	7 (-6.5, 27)	3.5 (-13.75, 24)	-0.740	0.459[b]	0.096

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).

a denotes two-sample independent t-test, b denotes Mann-Whitney U test.

Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 5. Between-Group Comparisons of Outcome Measures by Cognitive Rehabilitation Subgroup

Variables	Less than 60 minutes (n = 22)	60-120 minutes (n = 10)	Greater than 120 minutes (n = 51)	*F/H*	*P*	η^2/ε^2
MoCA	0.09 ± 3.35	-0.8 ± 1.62	0.65 ± 2.88	1.135	0.327[a]	0.028
AVLT-short delayed recall	0.23 ± 5.45	0.3 ± 4.32	0.82 ± 5.41	0.115	0.891[a]	0.003
AVLT-long delayed recall	-1 ± 3.27	0.5 ± 2.88	0.27 ± 2.73	1.684	0.192[a]	0.040
AVLT-recognition recall	-1 (-2, 0.25)	1.5 (0.75, 3) [c]	0 (-1, 1) [d]	8.557	0.014[b]	0.104
ROCFT-immediate recall	-1.73 ± 6.44	-2.4 ± 8.72	1.78 ± 8.27	2.216	0.116[a]	0.053
ROCFT-long delayed recall	-0.18 ± 5.72	-2.9 ± 7.45	1.24 ± 8.5	1.266	0.287[a]	0.031
ROCFT-copy time	11.5 (-61.25, 86.25)	27.5 (-52.5, 99.75)	0 (-90, 71)	0.993	0.609[b]	0.012
VFT	0.68 ± 3.51	0.1 ± 4.25	0 ± 3.89	0.246	0.783[a]	0.006
BNT	0.5 (-3.25, 3)	2 (-3.25, 4.5)	1 (-2, 3)	1.395	0.498[b]	0.017
STT-A	-0.5 (-10.25, 8)	16.5 (7.75, 31.25) [c]	-5 (-15, 6) [d]	14.48	< 0.001[b]	0.177
STT-B	10 (-29.75, 33)	1.5 (-66.25, 41.25)	4 (-38, 30)	0.609	0.738[b]	0.007
GDS-15	0 (-2, 1.25)	-1 (-5, -0.25)	0 (-1, 1)	2.623	0.269[b]	0.032
SAS	0 (-3.13, 4.06)	-0.88 (-8.44, 1.25)	0 (-3.75, 3.75)	0.933	0.627[b]	0.011
UCLA loneliness scale	-4.5 (-16, 3)	0 (-6.5, 4)	-4 (-10, 0)	2.122	0.346[b]	0.026
QoL-AD	0.95 ± 7.84	2.8 ± 5.25	2.49 ± 6.34	0.468	0.628[a]	0.012
ADL	0 (0, 0.25)	0.5 (0, 1.25)	0 (0, 1)	1.766	0.414[b]	0.022
BBS	0 (-2, 0)	0 (-1, 1)	0 (-2, 0)	1.037	0.595[b]	0.013
HPLP-II	19.55 ± 40.29	7.3 ± 30.26	13.75 ± 23.48	0.634	0.533[a]	0.016
SARHP	7.5 (-8, 30.25)	-10.5 (-23.25, 10.75)	5 (-8, 24)	3.683	0.159[b]	0.045

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).

a denotes One-way ANOVA, b denotes Kruskal-Wallis H test, c represents differences with less than 60 minutes, d represents differences with 60-120 minutes.

Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.

Table 6. Between-Group Comparisons of Outcome Measures by Cognitive Training Subgroups

Variables	Less than 60 minutes (n = 27)	60-120 minutes (n = 11)	Greater than 120 minutes (n = 45)	*F/H*	*P*	η^2/ε^2
MoCA	-0.26 ± 3.29	0.18 ± 2.86	0.71 ± 2.68	0.953	0.390[a]	0.023
AVLT-short delayed recall	-0.07 ± 5.55	2.45 ± 4.87	0.56 ± 5.17	0.908	0.408[a]	0.022
AVLT-long delayed recall	-0.7 ± 3.34	0.27 ± 2.41	0.29 ± 2.75	1.048	0.356[a]	0.026
AVLT-recognition recall	0 (-2, 2)	1 (-2, 2)	0 (-1, 1)	1.478	0.478[b]	0.018
ROCFT-immediate recall	-1.63 ± 6.75	1.45 ± 10.78	1.27 ± 7.89	1.234	0.297[a]	0.030
ROCFT-long delayed recall	-0.37 ± 6.23	-1.55 ± 7.54	1.27 ± 8.63	0.752	0.475[a]	0.018
ROCFT-copy time	6 (-57, 90)	0 (-48, 44)	10 (-91.5, 77)	0.225	0.893[b]	0.003
VFT	0.22 ± 3.51	0.64 ± 3.44	0.07 ± 4.11	0.098	0.907[a]	0.002
BNT	0 (-4, 3)	2 (-1, 4)	1 (-2, 3)	1.945	0.378[b]	0.024
STT-A	4 (-10, 10)	7 (-6, 17)	-2 (-13, 6)	3.049	0.218[b]	0.037
STT-B	10 (-45, 39)	15 (-11, 38)	3 (-41, 18)	2.001	0.368[b]	0.024
GDS-15	-1 (-2, 1)	-1 (-4, 0)	0 (-1, 1)	1.583	0.453[b]	0.019
SAS	0 (-5, 3.75)	-1.25 (-3.75, 1.25)	-1.25 (-4.25, 4.13)	0.264	0.876[b]	0.003
UCLA loneliness scale	-1 (-16, 5)	-6 (-8, 0)	-3 (-9.5, 0)	0.017	0.992[b]	0.000
QoL-AD	1.63 ± 7.36	4.45 ± 4.3	1.84 ± 6.61	0.795	0.455[a]	0.019
ADL	0 (0, 0)	1 (0, 2)	0 (0, 1)	3.822	0.148[b]	0.047
BBS	0 (-2, 1)	0 (-1, 0)	0 (-2, 0)	0.936	0.626[b]	0.011
HPLP-II	18.22 ± 36.05	5.55 ± 36.82	14.47 ± 22.56	0.720	0.490[a]	0.018
SARHP	6 (-9, 21)	3 (-20, 13)	5 (-10.5, 24.5)	0.536	0.765[b]	0.007

Note: Data in each group are expressed as change from baseline to post-intervention and presented as Mean ± SD or *median* (P_{25}, P_{75}).

a denotes One-way ANOVA, b denotes Kruskal-Wallis H test, c represents differences with less than 60 minutes, d represents differences with 60-120 minutes.

Abbreviations: ADL, Activities of Daily Living; AVLT, Auditory Verbal Learning Test; BBS, Berg Balance Scale; BNT, Boston Naming Test; GDS, Geriatric Depression Scale; HPLP-II, Health-Promoting Lifestyle Profile II; MoCA, Montreal Cognitive Assessment; QoL-AD, Quality of Life-Alzheimer's Disease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale; VFT, Verbal Fluency Test.ease; ROCFT, Rey-Osterrieth Complex Figure Test; SAS, Self-Rating Anxiety Scale; SRAHP, Self-Rated Abilities for Health Practices; STT, Shape Trail Test; UCLA loneliness scale, University of California, Los Angeles Loneliness Scale.