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Effects of Comprehensive Activity Training Program on Cognitive and Physical Abilities Among Older Adults with Mild Cognitive Impairment

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Abstract	Author Affiliation
Background/ problem: Mild cognitive impairment (MCI) in older adults often progresses to dementia, leading to reliance on assistance for physical abilities and daily living. Implementing an activity training program is essential for preserving cognitive and physical abilities. Objective/ purpose: The purpose of this study was to investigate the effects of a comprehensive activity training program on cognitive and physical abilities among older adults with MCI in Thailand. Design and Methodology: This study used a quasi-experimental pretest-posttest design. The comprehensive activity training program (CATP) was developed based on the social cognitive and self-efficacy theories. The participants were 124 older adults with MCI meeting the inclusion criteria and registered at the neurological clinic at a Thai university hospital. The experimental group (EG) received 14 CATP sessions, whereas the control group (CG) performed their daily living activities. Cognitive and physical abilities assessments were collected at baseline and at weeks 8 and 16. Data were analyzed using descriptive analysis and multivariate analysis of variance (MANOVA). Results: The sample mean age was 69.48 years, with 77.42 percent of participants being female. The cognitive and physical activities at weeks 8 and 16 were significantly better for the EG than for the CG. A repeated measures MANOVA between groups revealed a large effect size ($\eta^2 = .19$). Conclusion and Implications: The 14-week CATP significantly improved cognitive and physical abilities among older adults with MCI. Thai healthcare professionals can implement the CATP to enhance and sustain cognitive and physical abilities and thereby promote independent living within communities and gerontology-focused clinics.	¹ Faculty of Nursing, Thammasat University, Thailand. ² Frances Payne Bolton School of Nursing, Case Western Reserve University, USA. *Corresponding author e-mail: teeranut@nurse.tu.ac.th https://orcid.org/0000-0002-2394-2186 Article Information Received: 22.06.24 Revised: 02.08.24 Accepted for review: 02.08.24 Keywords Comprehensive activity training, cognition ability, physical ability, mild cognitive impairment

Mild cognitive impairment (MCI) is a common condition caused by a decline in cognitive function in older adults that manifests as impairment in memory, attention, decision-making, calculation, and executive function (Wiggins et al., 2020). Although MCI does not significantly interfere with daily activities (Miller, 2019), affected individuals may experience difficulties with memory, executive functions and decisions-making processes (Alfeo et al., 2024). In addition, they may take longer to perform more complex mental activities, and they may forget recent events (Qi et al., 2019). MCI can also lead to physical disability in terms of a loss of the ability to perform physical movements, self-transportation and advanced physical activities. This cognitive impairment-related adverse health condition in older adults arises via neurodegenerative processes (Vazini Taher et al., 2019). The consequences of physical disability in older adults can include obstruction of activities of daily living, such as walking upstairs, eating, dressing and bathing (Domínguez-Chávez et al., 2019). These disruptions to normal activities can lead to increased dependence on others among older individuals. Cognitive impairment and physical disability can lead to

dependency, which may become worse over time (Rodakowski et al., 2019). Therefore, maintaining both cognitive and physical abilities is a significant and necessary strategy for enabling older adults to continue to perform the activities of daily life for as long as possible.

Mild cognitive impairment is included under the umbrella of mild neurocognitive disorder (mNCD) as a transitional stage between normal cognitive ability and dementia (Miller, 2019). Recently, MCI has come to represent the prodromal phase of any form of dementia (Wiggins et al., 2020). According to the literature, MCI is associated with the decline of the nervous system and may go unnoticed because the changes are often non-specific and progress slowly (Untari et al., 2019). Although initially, cognitive decline may be barely noticeable and may show only slight exacerbations and remissions, the ultimate trajectory is always downwards (Touhy & Jett, 2018). The MCI is commonly classified into two subtypes: amnesic MCI, characterized by clinical memory impairment not meeting dementia criteria; and non-amnesic MCI, involving declines in attention, language, visuospatial, or executive functions (Wiggins et al., 2020). The risk of MCI in older adults increases with age, with an occurrence rate of approximately 2.15%–7.13% new cases per year in the general population (Untari et al., 2019). Between 5% and 17% of older adults with MCI may progress to dementia every year (Cheng et al., 2017). With the global increase in the aging population, the number of older adults with MCI has also risen (He et al., 2024). In Thailand, the prevalence of MCI among older persons is remarkably high, at 71.4%, and its prevalence is showing a concerning increase among those of advancing age (Griffiths et al., 2020). Thus, managing MCI in the older population is becoming an increasingly important public health issue in Thailand.

In general, MCI can be managed through pharmacological and non-pharmacological interventions aimed at delaying cognitive decline (Touhy & Jett, 2018). Non-pharmacological therapy for MCI is crucial because it helps reduce drug-related complications in older adults (Miller, 2019). Previous studies have proposed various user-driven interventions to improve cognitive ability in older adults (Chan et al., 2024; Petrovsky et al., 2021; Tian et al., 2022). For example, cognitive training programs for elderly patients with MCI can lead to improvement in their cognitive abilities (Griffiths et al., 2020). A recent meta-analysis of the combined administration of cognitive intervention and physical exercise in older adults with MCI confirmed that combining the two resulted in cognitive benefits and exhibited a limited superiority over the administration of cognitive intervention or physical exercise alone (Meng et al., 2022).

Other studies have also reported that simultaneous cognitive and physical interventions enhance cognitive abilities more effectively when administered together than alone (Roh et al., 2021; Yang, 2022). Cognitive and physical exercise can also help people recover their cognitive abilities and reduce the risk of long-term dementia (Vazini Taher et al., 2019). Moreover, integrated training yields more positive outcomes in older adults than when activities are performed separately, in term of their cognitive abilities (Yang, 2022). Nevertheless, to the best of the authors' knowledge, no previous studies have combined more than two tasks into one program. In addition, many studies have focused on the concurrent treatment of cognitive and physical disorders and have not been adequately targeted on the prevention of cognitive impairment in older adults. Up to the present, it has remained unknown whether applying multiple forms of activity training is optimal for preventing or delaying MCI in older adults.

The study aimed to develop a comprehensive activity training program (CATP), based on social cognitive theory (SCT) and self-efficacy theory, integrating multiple activities to maintain and enhance cognitive and physical abilities. The CATP component included health education, confidence building using sources of self-efficacy (enactive mastery experience, verbal persuasion, vicarious experience, and physiological and affective states) and multiple activity training. This approach prioritized specific activities over other cognitive training methods to ensure significant positive outcomes. Practice training started with easy activities and gradually increased in complexity. The CATP was adaptable to conditions requiring the use of various resources, thereby enabling the combination of more activities for older adults with MCI. Combining multiple interventions in the CATP was expected to yield better results than using single or dual interventions. Performing these interventions regularly would lead to improvements in physical, mental, psychological, and social health (Meng et al., 2022; Sun et al., 2021). Self-efficacy

enhancement would enable older adults to perform comprehensive activities successfully. The CATP could further demonstrate its potential value by showcasing its comprehensive impact on both cognitive and physical abilities. Accordingly, the purpose of this study was to investigate the effects of the CATP program on cognitive and physical abilities in older adults with MCI. The CATP was designed to preserve cognitive and physical abilities by promoting awareness of self-efficacy via continuous activities, with the goal of helping older adults to remain living independently for as long as possible.

Literature Review

This section reviews relevant previous studies that demonstrate the improvement of cognitive and physical abilities through various strategies, such as physical activity, cognitive training, art, and music. Multiple studies and meta-analyses have suggested that physical activity positively impacts both physical and cognitive conditions, and especially benefiting the executive function (Savikangas et al., 2021). For example, computerized cognitive training is efficacious for improving various memory domains in individuals with MCI (Chan et al., 2024). Social activities involving group interventions can enhance social interaction, stimulate social behavior, and significantly impact cognitive ability (Su et al., 2018).

Several studies have proposed theories on changes throughout the human experience include the social cognitive theory (SCT) and self-efficacy theory (Bandura, 1986). The SCT has been used in efforts to enhance behavioral function in older adults by increasing physical activity (Sansano-Nadal et al., 2019). Self-efficacy theory supports the value of helping a person become confident in their ability to perform certain behaviors (Resnick, 2018). Both of these theories can be used to enhance self-efficacy and behavior motivation and have positive impacts on health outcomes and intervention effectiveness (Islam et al., 2023). A meta-analysis of cognitive and physical training reported that the average duration of multimodal cognitive enhancement therapy was eight weeks, but varied between four and 40 weeks, with three sessions/week being the most common frequency of training (Meng et al., 2022). Moreover, the eight-week program of computerized cognitive training was shown to promote healthy cognitive aging in older adults (Ten Brinke et al., 2018). In the present study, the developed program was based on social cognitive and self-efficacy theories. It provided an initial eight-week intervention which took place in a hospital meeting room with the researcher, and a subsequent six-week intervention at home with family members. A frequency of three times per week was used for sessions, in order to achieve positive outcomes.

Theoretical Background

The theoretical background of this study was based on the SCT and the self-efficacy theory. Bandura's SCT proposed the concept of interaction based on triadic reciprocity (Bandura, 1986). The reciprocal determinism model has three components: personal, environmental and behavioral factors. All three of these factors, function interactively as determinants of one another (Bandura, 1986). First, the personal factors involve a cognitive process based on learning and observation through models and imitation processes. Secondly, the environmental and social factors act as structural models for driving cognitive learning and improving the interactivity process that enhances new knowledge and practical skills (Bandura, 1986). Thirdly, the behavioral factor results from the new knowledge that are contingent on expected outcomes (Bandura, 1986). Therefore, SCT correlates with the interactive dynamic relationships among persons, environments, and behaviors and can be used as a basis for intervention strategies and behavioral changes.

The concept of self-efficacy can be described as a person's belief in their ability to succeed in a particular situation (Resnick, 2018). The self-efficacy theory has four major sources: enactive mastery experience, verbal persuasion, vicarious experience, and physiological and affective states (Resnick et al., 2003). The significance of self-efficacy has two components, self-efficacy expectations, and outcome expectations (Resnick, 2018). Self-efficacy expectations refer to personal decisions about achieving goals, while outcome expectations focus on determining what will occur if an activity is completed (Resnick et al., 2003). The effects of self-efficacy on physical and cognitive performance proposed generally improves cognitive performance (Horcajo et al., 2022).

Research Objectives

This research aimed to investigate the effects of a comprehensive activities training program (CATP) based on the SCT and self-efficacy theory on improving cognitive and physical abilities in older adults with MCI. The program integrates multiple activities to promote sustainable improvements and support healthy aging.

Research Hypotheses

H1: Older adults with MCI who participate in the CATP will demonstrate statistically significant improvements in cognitive and physical abilities, as compared to those who do not participate in the program.

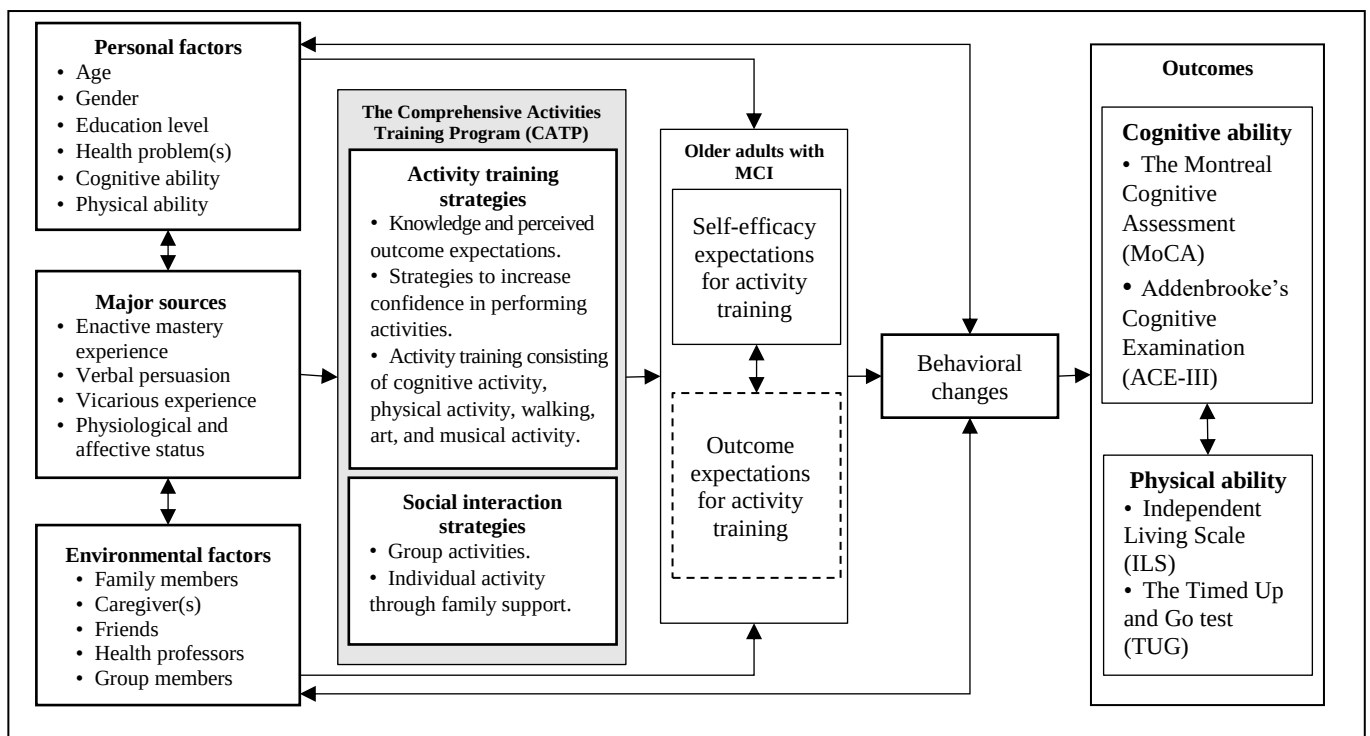
H2: Older adults with MCI will demonstrate statistically significant improvements in cognitive and physical abilities after 8 weeks and 16 weeks of participation in the CATP, as compared to their baseline scores.

Conceptual Framework

The conceptual framework of this study was developed based on SCT and self-efficacy theory. The proposed conceptual framework shown in Figure 1 is explained further. The SCT consists of personal factors (age, gender, education level, illness, and cognitive and physical abilities), environmental factors (group activities by healthcare providers and family members) and behavioral factors (comprehensive activity behaviors) (Bandura, 1986). Personal and environmental factors influence self-efficacy in older adults with MCI, thereby promoting behavioral changes (Bandura, 1986). The self-efficacy scales used to determine physical activity in older adults with MCI measure self-efficacy expectations and outcome expectations that can influence behavioral changes (Resnick, 2018). Self-efficacy is explored through major sources, including enactive mastery experience (sharing experience and discussion), verbal persuasion (speaking persuasively about good behavioral practices), vicarious experience (observing a life model with group activities) and physiological and affective states (emotional support during activities individually or in a group) (Resnick et al., 2003). Promoting self-efficacy in older adults with MCI requires activity training and social interaction strategies. The activity training strategies include educating participants on expected outcomes and increasing their confidence in performing various activities (Resnick, 2018).

Figure 1

Proposed Conceptual Framework



Multiple activities training consists of brain training, physical activity, art activity, and musical activity, which are carried out by the researcher. Brain training consists of reality orientation, games, word processing, calculations, memory games, and reasoning practice that could be attributed to working memory, orientation, language skills, calculation skills, abstract thinking, and executive function. Physical activities entail moving the body, through nine-square walking and physical exercises that encourage motor coordination, mood enhancement, and working memory function (Hsieh, 2019). Art activities, such as drawing, painting, and handcrafting, can benefit fine motor movement and coordination, meditation, memory and visuospatial function (Fioranelli et al., 2023). Musical activity, consisting of singing, listening, and social dancing, can motivate the coordination of motor activities, and elevate memory and mood (Kim et al., 2023). Strategies for increasing social interaction among health care providers, family support members, and older adults can help in furthering learning to achieve self-efficacy and outcome expectations and to engage in health behavior that leads to good behavior outcomes (Su et al., 2018). This study focused on CATP strategies as a means of enhancing self-efficacy and changing behavior to achieve a positive impact on cognitive and physical abilities. Physical and cognitive abilities were considered to be interdependent; when one ability improves, there will also be improvement in the other.

Method

Research Design

This research examines the effects of the CATP on cognitive and physical abilities among older adults with MCI using quasi-experimental designs. It involved pre-post-follow-up design with two participant groups, experimental group (EG) and control group (CG).

Participants/ Sample

The population of this study consisted of older Thai adults (aged 60 years or older) who had been diagnosed with MCI by a neurologist using the following criteria: A Clinical Dementia scale Sum of Boxes (CDR-SOB) score of 0.5 (Domínguez-Chávez et al., 2019), Montreal cognitive assessment (MoCA-T) score of 16–25 (Hemrungronj et al., 2021), and an Addenbrooke's cognitive examination III (ACE-T) score of 62–75 (Chareonboon et al., 2016). The research was designed specifically for the Thai population, as the intervention incorporates various Thai cultural elements such as idioms, songs and popular locations, all of which are deeply rooted in the Thai context.

The eligible sample in this study was older adults registered in the neurology clinic, at a university hospital in Thailand. The inclusion criteria was having a score of more than 60 on the Barthel index of activities of daily living (Barthel ADL), no depression, no dependence on a walking aid, the presence of family members to observe their activities, and the ability to communicate in the Thai language. People diagnosed with stroke, Parkinson's disease, severe cardiovascular disease, visual or hearing problems, or an active psychiatric condition were excluded from the study, as were those unable to attend more than two scheduled appointments. Data were collected from October 2022 to February 2023.

Sampling and Sample Procedures

The sample size of this study calculated by using power analysis of Cohen and influence estimation effect size (ES) from the study of Karssemeijer et al. (2017). This study was a meta-analysis which showed a positive small-to-medium effect of combined cognitive and physical interventions on global cognitive function in older adults with MCI. The study reported MoCA mean $\pm$ SD before and after 6 months of intervention than the effect size was 0.30. Sample size was calculated using the G*Power version 3.1 using F-test, MANOVA: repeated measures, within-between interaction, statistic significant at .05, power of test 0.80, number of groups 2, number of measurements 3. Calculated sample size is 111. When concerned dropout between study, therefore, in this study, the researcher increased the sample size by 10 percent. The sample size used in this study was total 124, divided into 62 for CG and 62 for EG. Participants who met the inclusion criteria were enrolled in the neurology clinic by a neurologist. The EG and CG were pair matched to have similar characteristics in terms of gender, age, and education level. Research assistants

randomly assigned the participants to the EG or CG to reduce sample bias and increase internal validity. Random allocation by the research assistants was conducted using a simple random lottery with a 1:1 ratio for the EG and CG on alternate weeks.

Instruments

Outcome Measures

Data was collected at weeks 8 and 16. The research assistant, who was blinded to the group allocation of the participants, conducted a self-efficacy outcome evaluation using the self-efficacy for physical activity (SEPA) scale, a measure of cognitive abilities and a measure of physical abilities via face-to-face assessments.

Self-Efficacy for Physical Activity Scale (SEPA). The SEPA scale, which was created by Harnirattisai et al. (2006) and modified from Resnick et al. (2003), was adapted for use in older Thai adults. The Thai version of SEPA was translated by a native language editor and then back translated to ensure accuracy. Assessment of the Thai SEPA's validity and reliability resulted in a high level of confidence. The SEPA demonstrated excellent reliability, as indicated by a Cronbach's alpha coefficient of .94. The SEPA was designed to predict confidence regarding the degree to which physical activity and behavioral changes would enhance cognitive and physical activity in older Thai adults with MCI. The details of the SEPA included 12 items with semantic differential scales ranging from 0 (no confidence) to 10 (total confidence).

Cognitive Ability. Cognitive ability was assessed using the Montreal cognitive assessment Thai version (MoCA-T) (Hemrungronj et al., 2021) and the Thai version of Addenbrooke's cognitive examination III (ACE-T) (Charernboon et al., 2016). The MoCA-T assesses short-term memory, visuospatial ability, executive function, attention, language skills and orientation. The ACE-T assesses attention/orientation, verbal fluency, language, visuospatial ability and memory. Both the MoCA-T and the ACE-T have excellent internal consistency, with inter-rater reliabilities of .94 and .88, respectively.

Physical Ability. Physical ability was assessed using the modified independent living scale (ILS) (Harnirattisai & Vuthiarpa, 2020), and the timed up and go test (TUG) (Mathias et al., 1986). The ILS assesses dressing, personal hygiene, care of personal possessions, food preparation/storage, health maintenance, money management, transportation, leisure and community, job seeking, job maintenance, social relations and self-esteem. There are 68 items, and a Likert scale ranging from 0 to 3 is used to identify the level of independent living ability. The total score reflects independent living ability, with higher scores indicating a greater degree of independence. The TUG measures the time taken for an individual to stand up from a chair with armrests, walk 3 meters, turn around, return to the chair and sit down. A total score of less than 10 seconds is considered to reflect normal physical ability, while a higher time range suggests abnormal physical ability. The Cronbach's alpha coefficient for the ILS is .93, and the TUG has good test-retest reliability (intra-class correlation coefficient of .98).

Procedure

CATP Intervention

The CATP was performed based on the SCT and self-efficacy theory. The SCT deals with interactions among persons, environments and behavior. The CATP consists of health education regarding cognitive impairment, confidence building to perform comprehensive activity and enhancement of continuous performance of activity on site by healthcare providers (week 1–8) and with family support at home (week 9–14). The self-efficacy theory considers how confidence can be increased by providing 4 sources of self-efficacy. The multiple activity training in the present study can be divided into types of activity: (1) physical and exercise activity; (2) brain training (games, calculations, Thai word and idiom activities); (3) music activity (singing, social dancing); (4) art activity (handcrafting, drawing, painting); and (5) social activity (group activities and discussions). The CATP and the handbook were reviewed for content validity by a panel of five experts: a neurologist, a psychiatrist, a special gerontological nurse, and two gerontological nursing instructors. The CATP was conducted in a manner that was appropriate for older adults, beginning

with easy continuous activities and gradually moving to more difficult ones. Sources of self-efficacy applied through teaching and discussion methods included enactive mastery experience (sharing experience and discussion), verbal persuasion (speaking persuasively on good behavior practice), vicarious experience (observing life models with group activities) and physiological and affective states (providing emotional support during individual or group activities).

In addition, the CATP logbooks were given to the participants. The function of the CATP logbook was to record the results of activities that stimulated cognitive and physical abilities after training. The details of the activity schedule are shown in Table 1.

Table 1
Details of the CATP

Session 1 (Week 1–8)	Monday (Meeting Room)	Wednesday & Friday (Home)
Week 1	Providing knowledge, brain gym exercise, strength/flexibility of muscles, jigsaw puzzle	Brain gym exercise, strength/flexibility of muscles, jigsaw puzzle
Week 2	Enhancing self-efficacy regarding activity, discussion and sharing experiences, paper clock making	Orientation of time via paper clock making
Week 3	Enhancing self-efficacy regarding activity, Thai word combinations and idioms	Thai word combinations and idioms
Week 4	Enhancing self-efficacy regarding activity, nine-square walking	Nine-square walking
Week 5	Enhancing self-efficacy regarding activity, math teasers and games	Math teasers and games
Week 6	Enhancing self-efficacy regarding activity, music memory games and singing	Music memory games and singing
Week 7	Enhancing self-efficacy regarding activity, problem-solving games	Problem-solving games
Week 8	Enhancing self-efficacy regarding activity, social dancing	Social dancing
Session 2 (Weeks 9–14)	Monday, Wednesday, & Friday (Home)	
Week 9	Cognitive skill practice	
Week 10	Jigsaw with memory task	
Week 11	Orientation of time via paper clock making	
Week 12	Thai word combinations and idioms	
Week 13	Nine-square walking	
Week 14	Math teasers and games	

Intervention Group

The researchers delivered the 14-week CATP with multi-dimensional activities to the EG. Similarly, the previous study of the effect of combined cognitive intervention and physical exercise on cognitive function in older adults with MCI proposed the sessions lasted 30 or 60 minutes and took place three times per week for 14 weeks, for a total of 42 sessions (Meng et al., 2022). In the initial phase (8 weeks), the intensive activities program was held every Monday for 60 minutes in the meeting room at the hospital or was conducted via an online meeting accessed from home by participants. In addition, every Wednesday and Friday, the participants completed the activity training at their homes with family members or caregivers supporting them during the 30-minute sessions. In the later phase (6 weeks), the intervention was conducted at home three times per week, with telephone reminders every week. CATP logbooks with a total of 42 entries were required to be completed for each participant. The participants underwent cognitive and physical ability assessments at baseline, week 8, and week 16.

Control Group

The CG participants engaged in their usual daily activities and did not receive the CATP or any other intervention during the 14-week study period. They engaged in their usual daily activities, family interactions, and community activities in daily life during the study. However, their cognitive and physical abilities were assessed at the same time points as the participants in the EG.

Statistical Methods

The data was analyzed using SPSS version 25. The participant demographic data was analyzed using descriptive statistics to determine the frequency, percentage, mean and standard deviation. All baseline demographic data and outcomes were tested for within- and between-group differences and compared using the chi-square test and t-test. The cognitive and physical ability scores, as well as the SEPA, were measured at baseline (T0 = Week 0), during the CATP (T1 = Week 8), and after the CATP (T2 = Week 16). The within- and between-group differences at the different time points were calculated using a one-way repeated measures multivariate analysis of variance (MANOVA). The interaction terms for the time point variables and groups (Group $\times$ T1, Group $\times$ T2) were included to assess the differential changes in each outcome at T1 and T2 relative to T0 between the two groups.

Data Analysis

Data were analyzed using IBM SPSS Statistics software version 26. First, descriptive analysis was used to examine the characteristics of the participants and variables. Secondly, the data was analyzed using one-way repeated measure MANOVA. The results of the preliminary analyses indicated the statistics assumptions as follows: (1) Normal distribution for the MANOVA Assumption was tested for MoCA, ACE-III, ILS and TUG; (2) Levene's test of the equality of variance matrix was greater than .01, thereby indicating no significant differences; and (3) Mauchly's test of Sphericity tested the difference of variance. The data did not violate the assumptions of normality and homogeneity of variance (Mertler & Vannatta, 2020).

Ethical Considerations

This study followed ethical guidelines for research. The researcher commenced with the process of protecting human subjects, including: (1) providing information on the objectives of the study to all participants before signing or thumbprinting informed consent forms; (2) allowing participants to decide to participate on their own by showing willingness to join; (3) keeping all data private, confidential and anonymously presented as overall results or collective effectiveness; and (4) stopping the training session and consulting with a neurologist when a participant had any problems during the training.

Results

Sample Characteristics

The participants consisted of 124 older adults; 77.42% were female and 22.58% were male, with ages ranging from 55 to 84 years old and a mean age of 69.48 years (SD = 7.54). Most participants had a high Barthel Index for Activities of Daily Living score (Barthel ADL) (91–100 points, 82.26%), although some had a moderate score (61–90 points, 17.74%). The outcome variables at baseline consisted of the SEPA score, cognitive abilities (MoCA-T and ACE-T scores) and physical abilities (ILS and TUG scores). Comparisons of the demographic and outcome variables at baseline indicated no statistically significant differences from homogeneity between the two groups, as shown in Table 2.

Descriptive Analysis

Table 3, show the results of a MANOVA conducted by the researcher to examine the interaction between time and group in terms of cognitive and physical abilities (Wilks' Lambda = .47, $F = 15.97$, $p < .00$). After the intervention, the dependent variables (MoCA, ACE-T, ILS and TUG scores) differed over time and between groups. Our results indicated that the CATP had a large effect size ($\eta^2 = .53$). A within-

subjects comparison conducted to determine whether the statistical significance of any changes within the groups or the measurements at the three time periods confirmed that the changes at the three time periods were significantly different ($F = 36.20, p < .00$). Statistically significant differences were detected between the test scores in the EG and CG ($F = 6.75, p = .03$).

Table 2*Demographic Characteristics and Outcome Variables at Baseline*

Sociodemographic Characteristics	Total ($N = 124$)	Experimental Group ($n = 62$)	Control Group ($n = 62$)	p -value
Gender, Female n (%)	96 (77.42)	49 (39.52)	47 (37.90)	.67
Age (years), M (SD)	69.48 (7.54)	70.40 (7.07)	68.55 (7.94)	.28
Barthel ADL, n (%)				.41
61–90	22 (17.74)	10 (8.06)	12 (9.68)	
91–100	102 (82.26)	52 (41.94)	50 (40.32)	
SEPA, M (SD)	91.41 (13.98)	92.84 (14.08)	89.98 (13.84)	.26
Cognitive Abilities				
MoCA-T, M (SD)	19.87 (1.99)	19.89 (2.03)	19.85 (1.97)	.78
ACE-T, M (SD)	70.86 (4.13)	70.73 (4.01)	71.00 (4.28)	.63
Physical Abilities				
ILS, M (SD)	157.54(12.1)	157.95 (11.43)	157.13 (12.97)	.27
TUG (Seconds), M (SD)	9.07 (1.48)	9.12 (1.57)	9.03 (1.40)	.26

Note. Barthel ADL = Barthel Index for Activities of Daily Living score, SEPA = Self-efficacy for physical activity scale, MoCA-T = Montreal cognitive assessment Thai version, ACE-T = Thai version of Addenbrooke's cognitive examination III, ILS = independent living scale, TUG = timed up and go test, M=mean, SD=Standard Deviation.

Table 3*Repeated Measures MANOVA of Average Scores of Cognitive and Physical Abilities Scores, Disaggregated by Group and Time Periods*

Variance	Wilks' Lambda	F -test	Hypothesis df	Error df	p -value	Partial Eta Squared
Between Subjects						
Intercept	.00	30509.09*	4.00	119	< .00	.99
Group	.82	6.75*	4.00	119	.03	.19
Within Subjects						
Time	.28	36.20*	8.00	115	< .00	.72
Time*Group	.47	15.97*	8.00	115	< .00	.53

Note. * $p < .05$

Outcomes of the CATP Intervention

Cognitive Ability. In the EG, the mean MoCA-T scores at T0, T1 and T2 were 19.89, 21.42 and 20.76, respectively, whereas the mean scores in the CG were 19.85, 19.84 and 19.69, respectively. According to the MoCA-T, the mean scores at T1 and T2 were significantly higher in the EG than in the CG ($F = 4.90, p < .00$; $F = 3.43, p = .00$). The mean ACE-T scores in the EG at T0, T1 and T2 were 70.73, 74.18 and 73.45, respectively, whereas the mean scores in the CG were 71.00, 70.89 and 70.84, respectively. Notably, the mean scores at T1 and T2 were significantly higher in the EG than in the CG ($t = 4.60, p < .00$; $t = 3.76, p < .00$). Moreover, in the EG, the mean ILS scores at T0, T1 and T2 were 157.95, 166.60 and 160.00, respectively, whereas the mean scores in the CG were 157.13, 155.92 and 153.26, respectively. The pairwise comparison showed that the differences in the mean MoCA-T and ACE-T scores at T0 vs T1, T0 vs T2, and T1 vs T2 were significantly different ($p < .05$). These results indicate that the CATP improved cognitive abilities during all time periods (Table 4).

Physical Ability. The mean ILS scores at T1 and T2 were significantly higher in the EG than in the CG ($t = 8.78, p < .00$; $t = 4.84, p = .00$). In the EG, the mean TUG times at T0, T1 and T2 were 9.12, 8.70

and 9.13, respectively, whereas the mean times in the CG were 9.03, 8.71 and 9.23, respectively. Notably, the mean times at T1 and T2 in the EG did not differ from those in the CG ($t = -.05, p = .96$; $t = -.37, p = .72$). The mean ILS scores at T0 vs T1, T0 vs T2, and T1 vs T2 were significantly different ($p < .05$). The mean TUG scores were significantly different at T0 vs T1 and T1 vs T2 ($p < .05$) but not at T0 vs T2 ($p > .05$). These results show that the CATP improved physical ability at some time periods (Table 4).

The results of mean scores in the EG of MoCA-T at T1 and T2 were 21.42 and 20.76, respectively. Similarly, the mean scores of ACE-T at T1 and T2 were 74.18 and 73.45, respectively. Moreover, the mean scores of the ILS at T1 and T2 were 166.60 and 160.00, respectively. The decrease of the cognitive and physical score in the EG may be caused by the irregularity of performing comprehensive training activities (Table 4).

Table 4

Post Hoc Comparison of Mean Cognitive and Physical Ability Scores at Different Periods by Time and Group

Variable/Time	Between Group				Within Group (Bonferroni)		
	Group	Mean ± SD	F	p-value	Mean Difference		
					T0	T1	T2
Cognitive Abilities							
MoCA-T							
T0	EG	19.89 ± 2.03	.09	.93	-	-1.53*	-.88*
	CG	19.85 ± 1.97				.02	.16
T1	EG	21.42 ± 1.68	4.90	<.00	-	-	.66*
	CG	19.84 ± 1.90				-	.15
T2	EG	20.76 ± 1.53	3.43	<.00	-	-	-
	CG	19.69 ± 1.90				-	-
ACE-T							
T0	EG	70.73 ± 4.01	-.37	.71	-	-3.45*	-2.73*
	CG	71.00 ± 4.28				.11	.16
T1	EG	74.18 ± 3.73	4.60	<.00	-	-	.73*
	CG	70.89 ± 4.21				-	.05
T2	EG	73.45 ± 3.41	3.76	<.00	-	-	-
	CG	70.84 ± 4.28				-	-
Physical Abilities							
ILS							
T0	EG	157.95 ± 11.43	.38	.71	-	-8.65*	-2.05*
	CG	157.13 ± 12.97				1.21	3.87*
T1	EG	166.60 ± 7.46	8.78	<.00	-	-	6.60*
	CG	155.92 ± 6.00				-	2.66*
T2	EG	160.00 ± 8.32	4.84	<.00	-	-	-
	CG	153.26 ± 7.13				-	-
TUG (seconds)							
T0	EG	9.12 ± 1.57	.33	.74	-	.41*	-.02
	CG	9.03 ± 1.40				.31*	-.21
T1	EG	8.70 ± 1.21	-.05	.96	-	-	-.43*
	CG	8.71 ± 1.44				-	-.53*
T2	EG	9.13 ± 1.33	-.37	.72	-	-	-
	CG	9.23 ± 1.65				-	-

Note. * $p < .05$, MoCA-T = Montreal cognitive assessment Thai version, ACE-T = Thai version of Addenbrooke's cognitive examination III, ILS = independent living scale, TUG = timed up and go test, T0 = Week 0, T1 = Week 8, T2 = Week 16.

Discussion and Conclusion

Discussion of the Main Results

The study investigated the effects of the CATP on cognitive and physical abilities in older adults with MCI and found that the mean scores for cognitive and physical abilities of the participants in the EG who participated in the intervention were higher than those for the CG. This outcome could be attributed to the development of the intervention, which is based on social cognitive theory and self-efficacy theory. The CATP integrated multiple activities based on literature reviews. Specifically, the combination of physical activity, cognitive training, music, art activities, and social interaction appeared to improve cognitive and physical abilities. Cognitive interventions, such as calculation and language skills, may have improved memory, visuospatial function, and executive function. Previous studies have reported that cognitive training involving a battery of neuropsychological tests targeting executive function was found to increase the levels of specific neurotransmitters (Ten Brinke et al., 2018). Furthermore, Tai Chi Chuan, a popular form of physical exercise, was found to improve blood circulation and motor ability in older adults with cognitive impairment (Cai et al., 2020). Musical activities can be an easy way to improve memory, language skills, mood and cognition, and participating in a music group was found to improve cognition, self-efficacy and emotional well-being (Kim et al., 2023). A study using Goldsmith's general musical sophistication index (Gold-MSI) revealed associations between four musical ability sub-factors and three cognitive abilities (Petrovsky et al., 2021). Given these previous findings, each component of the CATP is likely to have affected the mental and physical mechanisms that improve physical and cognitive abilities in older adults with MCI.

The post-intervention test scores for cognitive ability differed significantly between the EG and CG. The MoCA-T and ACE-T scores were higher in the EG than in the CG after the 14-week CATP, and this difference was statistically significant ($p < .001$). The mean cognitive ability scores were higher at week 8 and week 16 in the EG than in the CG. Thus, the CATP appears to have had a positive effect on cognitive ability in older adults with MCI. Previous studies have examined the effects of interventions in terms of improvements in cognitive function in individuals with subjective cognitive decline (SCD). For instance, one study described an intervention that improved objective cognitive ability and slowed the transition from SCD to MCI (Sun et al., 2021). Cognitive interventions and physical exercise have also shown cognitive benefits in older adults with MCI (Meng et al., 2022). Moreover, a study on the effects of a training program for older adults found increased muscle strength and cognition after the program (Roh et al., 2021). Similarly, multifaceted cognitive training appeared to be effective in delaying/preventing cognitive deterioration and cognitive functional decline in people with mNCD (Griffiths et al., 2020). Therefore, consistent with the present study, most previous studies on activity training programs have confirmed the benefits of such activities in improving cognitive ability, as well as delaying and preventing cognitive decline in older adults.

Several previous papers are relevant to the present study. For instance, one study found that musical activities significantly improved global cognitive function, verbal fluency, executive function and spatial function in older adults with MCI (Kim et al., 2023). This supports our results regarding the potential value of music activity in older adults with cognitive impairment. Moreover, active and receptive arts engagement is an effective approach for reducing cognitive decline and improving well-being in older persons (Fioranelli et al., 2023). This is consistent with our results, which support the roles of musical and artistic activities in improving neurocognitive abilities.

A further comparison of physical ability between the two groups revealed that the independent living scale (ILS) was significantly different between the EG and CG after the CATP, whereas this was not the case for the *timed up and go* test (TUG) score. The ILS score was significantly higher in the EG than in the CG after the CATP ($p < .00$). The mean ILS score in the EG was higher at week 8 and slightly lower at week 16, whereas the mean scores in the CG were lower than baseline at both week 8 and week 16. The TUG scores were not significantly different between the two groups. These results indicate that the CATP can improve ILS results but not TUG scores in older adults with MCI. This result might reflect the

insufficiency of the number of physical activity sessions included in the program. Alternatively, the TUG, which assesses physical balance, might not have been a suitable measure for this study. The objective of the CATP is to improve both cognitive and physical ability. A previous study on the efficacy of an integrated training device in improving muscle strength, balance, and cognitive ability in older adults indicated that cognitive ability improved at different time points (Roh et al., 2021; Yang et al., 2022). For instance, a cognitive training program in older patients with MCI improved cognition and daily living abilities between the two groups (Tian et al., 2022), whereas a combined intervention resulted in cognitive benefits in older adults with MCI, although with limited superiority over single cognitive interventions (Meng et al., 2022). Overall, previous relevant studies mainly obtained similar results regarding the effects of activity training programs on cognitive ability in older adults with cognitive problems.

Our comparison of changes in physical ability (ILS and TUG scores) between the EG and CG revealed the following: First, the ILS scores in the EG were significantly higher at week 8 (T1) and lower at week 16 (T2). At the same time, the ILS scores in the CG were lower at week 8 (T1) and week 16 (T2) compared with the baseline. These findings indicate that the CATP led to higher ILS scores when the older adults were carrying out activities with the researcher. However, when they trained at home with their families, the CATP was not as effective. Our present findings are consistent with those of previous studies (Roh et al., 2021; Savikangas et al., 2021) regarding the effects of multicomponent training. These results support the value of the adaptation and maintenance of a physically active lifestyle among older adults (Savikangas et al., 2021). Previous studies have shown that training effects, particularly concerning improvements in balance, muscle strength and cognitive performance, can be integrated into daily activities at different times (Roh et al., 2021).

These findings indicate that the CATP can improve cognitive and some physical abilities in older adults with MCI. Accordingly, this program could be implemented to improve cognitive and physical abilities, especially executive function and physical performance, in these older adults. These results suggest that significant improvements in cognitive and physical abilities were achieved through multiple activities, including across a range of familiar and less familiar cognitive and physical activities and games. By combining these activities, this program was able to improve individual performance to help maintain independence in older adults.

The findings of this study support SCT and self-efficacy theory. The interaction between personal factors, including cognitive factors, in people with high confidence in performing health behaviors, and their environmental factors can encourage older adults to perform health behaviors regularly to achieve successful cognitive outcomes. Similarly, the CATP could be utilized to assess self-efficacy and the outcome expectancy beliefs associated with osteoporosis medication adherence among elderly individuals, as well as interventions designed to reinforce these beliefs and enhance medication compliance (Resnick et al., 2003). Moreover, the evidence supporting a positive impact of SCT-based interventions on health outcomes and intervention effectiveness highlights the significance of integrating and evaluating the various conceptual frameworks of behavioral theories (Islam et al., 2023).

Furthermore, this data suggest that older adults with MCI who receive the CATP will exhibit significantly higher mean scores on cognitive and physical abilities after participating in the CATP at weeks 8 and 16 compared to their baseline assessment before receiving the CATP. Our findings suggest that the CATP has the potential to improve positive outcomes in older adults. However, an important point to note is that the mean scores of the MoCA, ACE-T, and ILS scales did not exhibit a statistically significant differences between weeks 8 and 16. These results indicate that continued follow-up and reinforcement of the intervention, potentially through healthcare provider-led activity training, may be necessary to sustain and enhance the observed improvements in cognitive and physical abilities.

Limitations

This study has several limitations. Firstly, it was conducted in only one setting, a tertiary-care hospital in Bangkok. Therefore, the findings have limited generalizability to other populations. Furthermore,

although only cognitive and physical abilities were measured to evaluate the effects of the intervention, the researchers did not assess brain function. A future study using biomarkers for brain function may be useful in evaluating the current results. In addition, some assessments used in the study did not yield clear outcomes, suggesting the limitations of some components for each activity in the CATP. The results indicated that the physical activity sessions were not sufficient to improve physical abilities, such as body balance and bone and muscle strength. Additionally, the application of SCT and self-efficacy may be limited for older adults experiencing mood and psychological challenges, as these issues can impede their engagement in confidence-building activities. Alternative theoretical frameworks, such as self-regulation and self-management, can be employed to support sustained behavioral changes and enhance independent living.

Implications for Behavioral Science

The intervention program was strategic in its promotion of health care, especially among older people who want to maintain independent lives without depending on other people for as long as possible. The CATP is one kind of intervention aimed at promoting better health care among older people that can be used by nursing professionals and healthcare providers. The results of this study show the positive effects of the CATP in terms of improving and maintaining cognitive ability with some physical ability. Therefore, nursing professionals who play a role in primary health care and registered nurses at secondary and tertiary hospitals can apply this program to older adults in many different settings, such as neurology clinics, gerontology clinics, community hospitals and patient home care in communities. Nurses could also consider integrating the CATP into routine healthcare during home visits and incorporating it into care plans or primary promotion centers. Nurses and healthcare providers can use the entire CATP or apply some parts for older adults who want to improve and maintain their cognitive and physical abilities. Implementation should guide the course of the CATP. The time spent in the program would be interesting to study in older adults who would like to do several activities for time spans such as 45-60 minutes per session. The intervention session should be conducted every other day or at least three times per week. This will provide a sufficient 14-week period to address the goals of improving cognitive and physical abilities. Some activity time should be spent on social dancing, singing and memory training, as these activities can enhance the social interaction and behavioral changes during group activity. Due to the decrease in cognitive and physical abilities in the later phases of the CATP, follow-up interventions should be carried out to maintain ongoing training activities and highlight the benefits of the program, especially at 8 weeks after the intervention. Moreover, nursing professionals should train health care workers to become special providers to offer the CATP to older adults with MCI.

The national policy in Thailand regarding older adults is a drive towards a 20-year national strategy to enhance the super-aged society with healthy ageing and active ageing. In this respect, the results of the present study showed how to encourage older adults to stay active and practice to prevent cognitive impairment. Therefore, policymakers who are responsible for the livelihoods of older adults should use the findings to implement healthcare programs and encourage healthcare providers to use the CATP to promote cognitive and physical abilities in multiple settings. The integration of health promotion is a necessary step in the challenge to encourage older adults to maintain independent living and to reduce household expenses as well as health expenditures at the national level. Moreover, self-efficacy also plays a role in maintaining the long-term benefits of CATP by focusing on building and increasing participants' confidence in their ability to perform daily tasks and maintain their independence.

Further Research

This intervention program might be tested in other settings, including hospital and community settings, to broaden the generalizability of the findings. The CATP can be expanded to include more physical activity sessions that improve physical abilities in older adults with MCI. Greater training and practice time should be offered for physical activity sessions, such as walking training, other exercises and physical movement. Furthermore, biomarkers of abnormal brain function, obtained using positron emission tomography or magnetic resonance imaging, could be used to track the progression of brain disorders with

respect to the effects of the CATP. Moreover, the physical assessment should specifically measure body balance, bone strength, and muscle strength. The integration of theories such as self-regulation and self-management is essential to support and sustain behavioral changes, particularly for older adults with mood and psychological challenges. This approach could significantly enhance independent living and overall well-being. Additionally, collaboration with experts in fields such as psychology, neurology, and geriatrics is crucial to develop a more holistic and comprehensive intervention program.

Conclusion

This study aimed to evaluate a comprehensive activity training program (CATP) based on SCT and self-efficacy theory. The program included health education, confidence-building activities, and multiple specific activity trainings. The findings of this study have indicated that the CATP positively affects cognitive and physical abilities, especially cognitive abilities (the MoCA, ACE-III). Moreover, the results of this study indicated that the CATP had a large effect size, which indicates the practical significance of a research outcome and is a measure of the meaningfulness of the relationship between variables or the difference between the groups. The large effect size observed in this study using the CATP among older adults with MCI means that the average individual in each group differed substantially. The study highlighted several limitations, including the single setting of a tertiary-care hospital in Bangkok, which limits generalizability, and the lack of brain function assessment, suggesting the need for future research using biomarkers. Future research should address the integration of theories such as self-regulation and self-management can support sustained behavioral changes, particularly for older adults with mood and psychological challenges. Collaborating with experts in psychology, neurology, and geriatrics will help develop a more holistic and comprehensive intervention program.

In conclusion, while the CATP shows promise in enhancing cognitive and physical abilities, further studies are necessary to optimize its components and expand its applicability across diverse populations. By addressing the identified limitations and incorporating additional theoretical frameworks, future research can contribute to more effective and comprehensive activity training programs.

Declarations

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Conflicts of Interest: The authors declare no conflicts of interest.

Ethical Approval Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Human Research Ethics Committee of Thammasat University, (Science) (No 084/2565 and October 3, 2022) and the Ethics Committee of Chulabhorn Royal Academy (No EC 022/2565, August 5, 2022).

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