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The Effects of the Brain Training Program on Cognition Among the Older Adults in Thailand

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Abstract

Background: **Dementia is typically found in older adults, and negatively impacts cognitive function. The current study examined the effects of brain training programs with learning activities on cognitive function in older adults.**

Methods: **We conducted a two-arm quasi-experimental study with participants who were over 60 years old and had Montreal Cognitive Assessment (MoCA) scores <25 (n = 66). The intervention group (n = 33) performed a brain training program with learning activities based on social cognitive theory. MoCA scores were evaluated at baseline, immediately after activities were completed at Week 9, and 3 months after the activities were completed.**

Results: **Sixty-six participants showed low MoCA. Mean MoCA scores at baseline in the control group (CG) and intervention group (IG) were 20.09 (SD = 2.89) and 19.82 (SD = 2.33), respectively; whereas MoCA scores immediately after activities were completed (Week 9) were 19.15 (SD = 2.06) for the CG and 24.24 (SD = 3.02) for the IG. Mean scores in the IG were significantly higher than those in the CG at Week 9 and 3 months ($p < 0.01$). Additionally, the mean cognitive function score in the IG at Week 9 and 3 months after the activities was significantly higher than the baseline ($F = 116.87$, $p < 0.01$).**

Conclusion: **The brain training program adopted in this study could be used with older people in the community. Healthcare providers should encourage older people to regularly practice brain training at home.**

Keywords: Dementia, Brain training programs, Delay and prevention of dementia, Older adults, Thailand

1. Introduction

The global population of older adults has increased dramatically in recent years, reaching approximately 703 million people aged 65 years or over in 2019. Moreover, it is projected to increase to 1.5 billion in 2050 [1]. In 2019, the number of older adults in Thailand was approximately 12 million, accounting for 18.1 % of the Thai population [2]. Furthermore, projections in Thailand indicate that there will be approximately 15.1 and 17.6 million older adults in 2025 and 2030, respectively [3]. Because of this dramatic increase in the number of older adults, Thailand will become a completely aged society in the coming years [2]. Older adults experience not only physical decline but also cognitive deterioration. Impairment of cognitive function, including dementia, is an important challenge for older adults [4]. In 2020, there were 47 million people with dementia worldwide [5]. One study estimated that the number of people with dementia globally will increase to 75 million and 135 million by 2030 and 2050, respectively [5]. In Thailand, it has been reported that approximately 2 %−10 % of older adults suffer from dementia [6,7]. Another report found that the prevalence of dementia is rising in low- and middle-income countries (LMICs) where the population 60 years and older is increasing [8].

Dementia is a syndrome resulting from the dysfunction of the cerebral cortex and abnormal brain changes. The critical signs and symptoms of dementia include impairments of memory, decision-making, abstract thinking, problem-solving, use of language, calculation, attention, movement skills, and personality [9]. Severe symptoms of dementia can become barriers to activities of daily living. Dementia may affect these aspects of a

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person's life: (1) physical aspects (i.e., cognitive function deficits), (2) psychological aspects (i.e., anxiety, depression, aggression, frustration), (3) social aspects (i.e., role function impairment, family/social isolation, loss of self-confidence), and (4) emotional aspects (i.e., loss of self-efficacy) [10,11]. Dementia has a negative impact on older adults' cognitive function and activities of daily living resulting in dependence on caregivers. These negative impacts can create a burden for families and caregivers. Thus, prevention of cognitive deterioration is essential for decreasing the dependency of older adults on their families and society.

Teaching older adults about dementia, improving cognitive function, and encouraging them to participate in social activities can delay or prevent dementia [7]. Various types of therapy and exercise have also been shown to help improve cognitive function. A previous study reported that occupational therapy involving cognitive training exerted positive effects on the maintenance of the global cognitive state of older adults with dementia and significantly improved their comprehension of verbal commands and praxis [12]. Furthermore, evidence from a systematic review indicated that exercise could increase brain function in older adults [13].

Several types of brain stimulation such as brain training, physical exercise, visual art therapy, and aerobic dance [14–16] are linked with positive outcomes. The brain training that we used in our study contained language games, calculation, thinking, and decision-making practice. These activities are similar to a previous study which sought to improve cognitive function [12]. Furthermore, our study's brain training activities included the use of group reflections, positive reinforcements, and cultivation of positive attitudes toward learning. These activities were similar to those used in another study which found brain training on perceptual capacities and games increased cognitive function [17]. A study on the effects of computerized cognitive training in older adults suggested that computer programs combined with brisk walking were more effective for stimulating perceptual capacities than regular classroom training among older adults [18].

Previous studies have shown mostly positive impacts of exercise, brain training, and therapy on cognitive function among the elderly, In one study, performing aerobic exercise for at least 30 min two times weekly and cognitive activity training were reported to reduce the risk of developing dementia in older adults [19]. Moreover, performing brain training for 90 min one to two times per week for 3 months increased older adults' brain function and maintain their ability to perform activities of daily living [14]. The effects of visual art therapy and cognition were sustained cognitive functions at 6 weeks and 3 months follow-up [15]. Yet, in a different study, there were no statistically significant effects of a 6-week cognitive stimulation program on the cognitive function after 5 weeks of treatment (week 5); but cognitive function significantly improved after 6 weeks of follow up (week 12) [12]. In our study, we elected to make each session for learning activities 120 min long. This session length is similar to another study in which brain training was provided to participants for 120 min per week over a 5-week period [20] and previous studies designed to improve cognitive function [20]. However, current knowledge about cognitive activity training to improve behavior to prevent dementia in older adults is limited; therefore, and further research is needed.

In our study, we sought to design a program to help older adults achieve the learning process to improve their physical and mental status. When designing our program, we utilized the concept of social cognitive theory (SCT) or social cognitive learning theory, which was developed by Albert Bandura, a social psychologist. Bandura said that learning that explains a person's behavior, person, and environmental factors around such person [21]. Self-efficacy occurs when a person is able to evaluate themselves to have management potential and control their own behavior to achieve desired goals [22]. Based on SCT, the goal of our brain training program was to enhance cognitive function through the learning process. Brain training programs comprised a range of learning activities. They were designed to stimulate cognitive functions such as learning, memory, reasoning, decision-making, and problem-solving. The program consisted of playing games, learning skills, drawing, sensory skills, and brain gym exercises that follow life modeling [12,13,23]. The researchers provided each activity in 120-minute sessions [20]. Each activity was designed to enhance cognitive function. For instance, playing games improves both memorization and language skills. Brain gym exercises were designed to affect sensory perception and motor coordination.

The current study examined the effectiveness of a 9-week brain training program involving learning activities for older adults immediately after (Week 9) and 3 months after the activities were completed. We hypothesized that: (1) The intervention group would improve their cognitive function after receiving the brain training program in comparison to the control group; and (2) Compared with baseline, the intervention group would have a higher cognitive function score immediately after the intervention activities were completed (Week 9) and at 3 months after the intervention activities were completed. The intervention program was developed to improve older adults' ability to process cognition and memory. The ultimate goal of the program was that older adults maintain their cognitive function and activities of daily living without depending on their caregivers or families.

2. Methods

2.1. Study design

This study was a two-arm quasi-experimental study with a wait-list control group conducted at a tertiary hospital in Bangkok, Thailand.

2.2. Study participants

Participants were recruited between January and April 2020. Recruitment was performed by a community leader using convenience sampling. We calculated a minimum sample size of 66 participants using the G*Power analysis program with an effect size of 0.65 of a previous study that similar to this study [23]. At total of 68 participants were needed in the IG and CG to reach the power of 0.8 at a 0.05 level of significance with a 10 % dropout rate for participation. The inclusion criteria included: (1) age 60 and over; (2) MoCA score 25 or less; (3) ability to read and write in Thai; and (4) willingness to participate in the study. Potential volunteers were excluded from the study if they had acute or severe medical conditions. Seventy-six volunteers were screened for eligibility. Sixty-eight volunteers met the inclusion criteria and gave informed consent. Participants were randomly assigned to either an intervention or a control group using matched pairs on the basis of age, gender, and MoCA score. A Chi-square test was used to compare the characteristics of participants between groups before intervention. The results showed no significant differences in participants' characteristics between groups ($p > 0.01$). Two participants were lost after failing to follow up after assignment (control $n = 1$, experiment $n = 1$). Thus, the total sample size at analysis was 66 participants (control: $n = 33$; intervention: $n = 33$).

2.3. Brain training program

The brain training program with learning activities was developed on the basis of Bandura's social cognitive theory (SCT) [21]. The concept of SCT is that cognitive social learning stimulates intellectual thought processes, the acquisition of new knowledge, observation, imitation, self-efficacy, and reinforcement. All of these processes influence learning behavior and the practice of various skills [24–26]. The objective of this approach is to develop practical skills and promote positive behaviors that are reinforced during each session. The program focused on learning activities and cognitive skill enhancement. The activities were delivered by the researchers to participants in nine sessions lasting 120 min each. Weekly activities were conducted in the hospital conference room for a duration of nine weeks. Session 1 involved introductions, icebreakers, and explaining activity goals in order to improve the basic knowledge and learning skill. Sessions 2–5 involved playing games and engaging in learning activities designed to help train the brain that enhance the learning skill, memories, attention, calculation, and executive function. In addition, participants were encouraged to tell inspirational stories, provide positive reinforcement, share ideas, and reflect during and after the activities with their fellow participants. The learning activities were designed to promote the development of six skills, namely memorization, language, thinking, decision-making, calculation, and sensory perception. Each activity implemented multiple learning techniques such as modeling and lecturing during exercises and brain training games. In sessions 6–8, the researchers contacted the participants via telephone to motivate them to practice at home in order to maintain the ongoing activities. In the final session, researchers worked with participants to summarize the activities.

2.4. Measurements of cognitive function

Cognitive function was measured using the Montreal Cognitive Assessment (MoCA). The MoCA is an instrument that assesses a person's ability to perform activities including attention, executive function, memory, language, visuoconstructional skills (ability to organize and manually manipulate visual and spatial information to make a geometrical design), conceptual thinking, calculations, and orientation [9]. The maximum scores were 30 points, with scores of 26 or more indicating no cognitive impairment. The cut-off score of cognitive impairment was less than 25 points [27]. The internal consistency of the Thai-MoCA test had a Cronbach's alpha coefficient of 0.74. The sensitivity and specificity values of the MoCA for amnestic mild cognitive impairment (aMCI) were 0.70 and 0.95 [28]. The sensitivity and specificity of the MoCA for Alzheimer's disease were 0.80 and 0.95 [28]. This instrument was validated for reliability and produced a Cronbach's alpha of 0.82 and a content validity value of 0.92.

2.5. Intervention group and control group

Thirty-three intervention participants were divided into small groups, which consisted of six to seven people. The participants were evaluated using the MoCA questionnaire at baseline (T0), immediately post treatment (Week 9) (T1), and at 3 months after intervention (T2). Each small group participated in session 1 to receive orientation information about the study, icebreaker, and activity goals. The participants practiced the activities to train the brain for 120 min once a week for 5 weeks. The activities within the brain training program included learning activities, inspirational stories to encourage participants to understand the importance of brain training, reviewing, and reflections. These activities were designed to stimulate learning, promote brain exercise, and encourage regular practice among participants. The activities, games, and exercises (e.g., jigsaw puzzles, proverb puzzles, math games, and math problems) were specifically designed to enhance various skills within the cognitive domain. In Weeks 6–8, participants practiced what they had learned in the class at home. The researchers followed up with the participants via telephone for approximately 15–20 min. Participants were invited to ask questions regarding the brain training activities. Additionally, participants underwent testing of language, calculation, thinking, and decision-making. In Week 9, all participants joined activities in the same class for 120 min. If the participants did not participate in class more than twice, they were considered to have dropped out of the study. The meeting room provided the space to conduct the intervention for the participants.

During weeks 0–21, participants in the control group did not receive any brain training activities. After week 21, the control group learned the same brain training program as the participants in the intervention group.

2.6. Statistical analysis

Data were analyzed using SPSS statistics, version 25. The demographic data of the samples were analyzed by using descriptive statistics including frequency, percentage, mean, and standard deviation. All of the baseline demographic data were tested for differences between groups and compared by using Chi-squared testing and t-test. We performed testing and calculated participants' cognition scores at baseline (T0), after completion of the intervention (T1 = Week 9), and follow up (T2 = Week 22). Next, we compared the differences within and between groups at different time points by using one-way repeated measurement ANOVA. The interaction terms of the time point variables and group (Group x T1, Group x T2) were included to assess the differential changes of each outcome at T1 and T2 relative to T0 between the two groups.

2.7. Ethical statement

The study was reviewed and approved by the Chulabhorn Research Institute Institutional Review Board Data (No. 027/2561) on 8 February 2019.

3. Results

3.1. Demographic characteristics

Demographic characteristics for the 66 eligible participants is shown in Table 1. Characteristics of participants were balanced between two groups at baseline. The mean age was 66.79 years (SD = 5.53) for the control group and 69.97 years (SD = 6.19) for the intervention group.

Table 1. Demographic characteristics of participants.

Characteristics	Control group	Intervention group	*p*-value
	N (%)	N (%)	
Gender			0.418
Male	5 (15.15)	12 (36.36)	
Female	28 (84.85)	21 (63.64)	
Average age (years) ± SD	66.79 ± 5.53	69.97 ± 6.19	0.098
Educational level			0.834
Less than elementary school	0 (0)	1 (3.03)	
Elementary school	8 (24.24)	9 (27.28)	
Junior high school	3 (9.09)	8 (24.24)	
Senior high school	11 (33.34)	5 (15.15)	
Bachelor's degree	10 (30.30)	7 (21.21)	
Postgraduate degree	1 (3.03)	3 (9.09)	

Note(s): N = Number of total participants; SD = standard deviation.

3.2. Baseline Montreal Cognitive Assessment (MoCA) score

At baseline evaluation, the mean MoCA scores in the control and intervention groups were 20.09 (SD = 2.89) and 19.82 (SD = 2.33). The MoCA scores were not significantly different between two groups at baseline (p > 0.01) (Table 2).

3.3. Comparison of MoCA scores between groups at each time point

According to an independent t-test, there was no significant difference between the MoCA pretest scores of participants in the intervention group and control group. The mean scores of the MoCA immediately after the activities at 9 weeks follow up were significantly different in the control group (19.15; SD = 2.06) and intervention group (24.24; SD = 3.02) (p < 0.01). In addition, the mean scores of the MoCA 3 months after the activities in the control group (20.15; SD = 2.27) and intervention group (24.42; SD = 2.83) were significantly different (p < 0.01). Thus, these results from immediately after the completion of activities (Week 9) and at the 3-month follow-up confirmed the first research hypothesis; they suggested that participants who underwent the brain training program achieved higher scores than those who did not. Hence, the brain training program appeared to be effective for enhancing MoCA performance. However, the improvement in mean MoCA scores in the control group from Week 9 to the 3-months follow-up was an increase of 1 point, which is more than the corresponding increase of 0.22 points in the intervention group. These results suggested that the intervention might be influenced by confounding factors that the control group received the brain training program (Table 3).

3.4. Comparison of Montreal Cognitive Assessment (MoCA) scores within groups at different time points

One-way repeated measures ANOVA was used to compare the MoCA results across the study timeline including before the activities, immediately after the activities (Week 9), and 3 months after the activities. The analysis revealed that the scores produced by those in the program at different periods were significantly different from each other (F = 116.87, p < 0.01). These results confirmed the second research hypothesis that MoCA scores changed over time with respect to participants receiving the learning activities. The effect size of the partial η^2 value was 0.79, so the influence of the brain training program was sufficiently large to impact participants' MoCA scores (Table 4).

3.5. Comparison of Montreal Cognitive Assessment (MoCA) scores within groups using a Least Significant Difference (LSD) pairwise comparison

A LSD pairwise comparison was used to examine the MoCA scores of participants who underwent the brain training program before, immediately after (Week 9), and 3 months after the activities. Using pairwise comparisons, the mean MoCA pretest scores were significantly lower than those immediately after the activities (Week 9) (mean = 19.82 and 24.24, respectively; p < 0.01; d = −4.42). Similarly, MoCA scores in the pretest for each pair were significantly lower than those 3 months after the activities (mean = 19.82 and 24.42; p < 0.01; d = −4.61). Although MoCA scores immediately after the activities (Week 9) appeared to be lower than those 3 months after the activities (mean = 24.24 and 24.42, respectively), the differences were not statistically significantly different at a level of p > 0.01 (p = 0.08, d = −0.18) (Table 5).

Table 2. MoCA pretest scores before the brain training program in the intervention group (n = 33) and control group (n = 33).

MoCA Score	Control group (n = 33)	Intervention group (n = 33)	t-test	*p*-value
Mean (SD)	20.09 (2.89)	19.82 (2.33)	−0.42	0.67

Note(s): SD = standard deviation; n = number of cases; t-test = independent t-test.

Table 3. Comparison of mean Montreal Cognitive Assessment (MoCA) scores and standard deviations between participants in the intervention group (n = 33) and the control group (n = 33).

Timeline	Control group	Intervention group	t-test	df	*p*-value
	Mean (SD)	Mean (SD)			
Before the activities	20.09 (2.89)	19.82 (2.33)	−0.42	32	0.67
Immediately after the activities[a]	19.15 (2.06)	24.24 (3.02)	7.99	32	<0.01*
Three months after the activities	20.15 (2.27)	24.42 (2.83)	6.77	32	<0.01*

Note(s): *p-value <0.01; SD = standard deviation; t-test = independent t-test; df = degree of freedom.
[a] Scores were measured immediately after the in-person learning activities were completed at Week 9.

Table 4. Comparison of Montreal Cognitive Assessment (MoCA) scores measured before, immediately after (Week 9), and 3 months after the activities in participants in the intervention and control groups using one-way repeated measures ANOVA.

Variance	SS	df	MS	F	p-value	partial η^2
Control group (n = 33)						
Assessment period	20.75	2	10.51	4.64	0.61	0.13
Error	143.25	64	2.27			
Total score	164.00					
Intervention group (n = 33)						
Assessment period	449.52	2	224.53	116.87	<0.01*	0.79
Error	122.95	64	1.921			
Total score	572.47					

Note(s): *$p < 0.01$; SS = sum of square; df = degree of freedom; MS = mean square; F = F-test; partial η^2 = partial eta squared.

Table 5. Least Significant Difference (LSD) pairwise comparison of Montreal Cognitive Assessment (MoCA) scores of participants in the intervention group (N = 33) before, immediately after (Week 9), and 3 months after the activities.

MoCA scores of the participants in the intervention group	Mean	Mean difference	Std. Error	*p*-value
Before vs. immediately after the activities	19.82 vs. 24.24	−4.42	0.43	0.00
Before vs. three months after the activities	19.82 vs. 24.42	−4.61	0.39	0.00
Immediately after the activities vs. 3 months after the activities	24.24 vs. 24.42	−0.18	0.10	0.08

Note(s): * *p*-value < 0.01; Std. Error = standard error; vs. = versus.

4. Discussion

The current results revealed that participants who received the brain training program produced significantly higher Montreal Cognitive Assessment (MoCA) immediately after the activities (Week 9) and 3 months after the activities scores compared with those who did not receive the program. The findings demonstrated the efficacy of the brain training program grounded in the principles of social cognitive theory (SCT) in enhancing cognitive functioning among older adults. As mentioned earlier, this study utilized the principles of SCT to enhance behavioral changes and improve cognitive function through interpersonal learning utilizing modeling techniques. Similarly, in a research study on chronic disease self-management and behavioral change attitudes in older adults, SCT participants were motivated or discouraged from making changes based on the significance of the risk behavior to the individual [29]. In addition, the research regarding the alteration in the quality of life and the social cognitive outcomes in older adults based on the SCT presents a construct that reflect individuals' convictions in their capacity to be successful [30]. Moreover, the stimulation, incentivization, positive reinforcements, and modeling should be promoted based on SCT to create behavioral transformation to prevent or delay the onset of dementia [31].

A comparison of the MoCA scores for the pretest, immediately after the activities (Week 9), and 3 months after the activities scores revealed that participants in the program achieved significantly different scores at different time points. The average scores peaked 3 months after the activities; the average scores at 3 months were higher than immediately after the activities (Week 9) and for the pretest (baseline). Furthermore, the results suggested that the brain training program influenced cognitive performance with a large effect size. Thus, the program appeared to be effective for increasing MoCA scores and promoting participants' perceptual capacities. The LSD pairwise comparison indicated that mean MoCA scores assessed before and immediately after the activities (Week 9) were significantly different. Similarly, the difference between scores obtained at baseline and 3 months after the activities reached statistical significance. However, the mean scores obtained immediately after (Week 9) and 3 months after the activities were not significantly different. Possible explanations may be that participants did not continue with self-practice of the learning activities or that their practice lacked consistency.

The lack of substantial difference in mean MoCA scores at 3 months after the activities and those immediately after the activities (Week 9) were in accord with the findings of a previous study investigating a brain training program that was based on the Montessori philosophy and Islamic way of life. The previous study reported that mean cognitive scores obtained 4 weeks after the training program were higher than those obtained before the experiment [32]. Yet, a comparison of mean cognitive scores obtained before and 9 weeks after the experiment, as well as a comparison between 4 weeks after and 9 weeks after the experiment, revealed no differences. This phenomenon may have been caused by decreased activity frequencies and individual activities.

As suggested by Hsieh and colleagues, the effects of multiple training modalities contributed to greater improvement in recent memory function and affect cognitive scores [33]. Although previous participation could lead to the storage of information in long-term memory, deterioration of brain function is likely to occur without further activities and regular stimulation to aid cognitive processing [34]. Therefore, to prevent or delay dementia in older adults, it is vital to encourage individuals to train their brains by regularly participating in thought-provoking activities. Self-conducted daily routines should be adapted to encourage brain training.

However, this study has some limitations; we also have corresponding recommendations. The training program in this study had a short duration; the study 's length may not have been sufficient for a comprehensive evaluation of cognition in older adults. The systematic review reported the duration of the brain health interventions ranged was from 2 weeks to 36 months. In this review, interventions with longer durations could improve cognitive function and delay the brain's deterioration [35]. Therefore, a longer training program should be examined in future studies. Moreover, future training programs should provide a wider range of interventions, such as physical exercise, brain stimulation, and music interventions. Brain training programs could be applied with older people in healthcare facilities and the community.

5. Conclusion

The use of the proposed brain training program is recommended for older adults, including those at risk of developing dementia and those with mild cognitive impairment. The application of these activities is also recommended for older people in healthcare facilities, local communities, and clubs for older adults. Nurses and healthcare professionals running these activities should initially examine the underlying conditions of the older people in their care and establish an in-depth understanding of the care needs of each individual. Each of the activities in the program may have a psychological impact on older adults. Hence, efforts should be taken to ensure that interactions with older adults are positive, including the use of appropriate communication etiquette considering the individual's underlying conditions, and the promotion of motivation and positive reinforcement. The goal of this process is for the individual to maintain a positive attitude while participating in activities so that they can learn more effectively and commit to long-term engagement in the activities. Effort should also be made to encourage older individuals to further choose and adopt these activities as regular practices at home. Nurses and healthcare providers should encourage older people to regularly practice brain training at home and maintain their cognitive function for as long as possible.

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Conflicts of interest

None.

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