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# Effects of Dual Tasks Training on Balance Performance and Cognitive Functions in Older Adults with Mild Cognitive Impairments: A Randomized Controlled Study

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**Abstract**

Mild cognitive impairment (MCI) is a condition of older adult who are at the transitional state between the cognitive changes of normal aging and very early dementia. Numerous studies have established that mild exercise or cognitive training has positive effects on physical and cognitive functions in healthy older adults. Newly, the possibility of combined of physical exercise and cognitive training get noticed in the older adults with MCI. The objective of this study is to investigate the effect of mild exercise with cognitive training in older adults with MCI on measures of balance performance and cognitive functions. Ninety older adults with MCI were randomized into three groups. Mild exercise (ME) group (n = 30) underwent chair-based exercise, cognitive training (CT) group (n = 30) received Stroop color and word task training, while the mild exercise with cognitive training (ME+CT) group (n = 30) received both of them in the same time. In terms of demographic characteristics, there was no significant differences among three groups in baseline data. All groups underwent the training for 45 minutes per sessions, 12 training sessions within 30 days. Participants were evaluated for balance performance (via Mini-Balance Evaluation Systems Test (Mini-BESTest)) and cognitive functions (via Mini-Mental State Examination (MMSE)) prior to the training and then we immediately re-assessed after training. Significant main effects of group in Mini-BESTest ($p=0.003$) and MMSE ($p = 0.037$), and main effect of time in Mini-BESTest ($p = 0.033$) and MMSE ($p = 0.012$) (ME+CT > CT > ME group) were found. The ME+CT group also demonstrated improved balance performance and cognitive functions compared to the ME or CT group (post-training > baseline). A combination of mild exercise and cognitive training can improve balance ability and cognitive functions in older adults with MCI as well as mild exercise or cognitive training. It might be beneficial effect for delaying the declining functional capacity in older adults with MCI.



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## Introduction

Population ageing is a global phenomenon. The number of older people is increasing. In 2019, the United Nations reported that the number of older people worldwide stood at 1 billion worldwide. Over the next three decades, the number of older people is projected to increase to more than 1.5 billion persons in 2050. The older adults have been defined by World Health Organization (WHO) as the person who has the chronological age of 65 years old or older (World Health Organization, 1999; Orimo et al., 2006).

Thailand is the second highest age population in the Southeast Asia region. It is estimated that the number of older people will increase by 12 million to 17 million by 2030. There is numerous evidences that has reported that the older people with increasing age have declining balance ability, functional capacity, and cognitive functions (Jaul & Barron, 2017; Maneeprom, et al., 2018; Thaweewannakij et al., 2013; Tiraphat & Aekplakorn, 2018). In addition, the older adults with declining cognitive functions were at increased risk of dementia (Sacuiu et al., 2018). The physical and cognitive decline could be occurred in the older adults, and may present as decreased muscle strength, the impaired balance control, and slower walking speed (Deandrea et al., 2010; Laughton et al., 2003).

Mild cognitive impairment (MCI) is a condition of older adult who are at the transitional state between the cognitive changes of normal aging and very early dementia (Petersen & Negash, 2008). MCI is characterized by: preserved general cognitive function, objective memory impairment following increasing age, lack of dementia, and little or no impairment of activities of daily living (ADL) (Petersen, 2004; Dubois & Albert, 2004; Portet et al., 2006). A previous review international study found that the prevalence of MCI varies widely from around 3% to 42% (Ward et al., 2012). Previous studies of the prevalence of MCI in Thailand reported MCI ranged from 16.7 %to 71.4%. These evidences were different depending on the methodology of study that included age range of older adults, education level, outcome measures and the areas of study (Griffith et al., 2020; Deetong-on et al. 2013; Kengsakul et al., 2015; Sangsirilak, 2016).

Consequences of older adults with MCI demonstrated that they have lower quality of life that the elderly individuals that are healthy (Hussenoeder et al., 2020). Specifically, the MCI has significant impact on postural balance in older adults. A recent previous study found that MCI was associated with balance deficits which related impaired central processing of visual information that is critical for balance control (Bahureksa et al., 2017; Liu et al., 2020). Moreover, balance performance was associated with cognitive function in individuals with MCI. Tangen and co-workers investigated the relationships between balance and cognition in individuals with MCI. They found that cognitive function as the executive function was associated with balance performance in individuals with MCI as shown in Balance Evaluation Systems test (BESTest) (Tangen et al., 2014).

Mild exercise or low-intensity exercise is useful to enhance health benefits for older adults and better exercise adherence that related to the moderate-and high-intensity exercise (Sanders et al., 2020; Tse et al., 2015; Brown et al., 2000). The low-intensity exercise might offer both physical and cognitive improvements in older adults. The common types of mild exercise include chair-based exercise, Tai Chi, walking, or stretching exercises. (Tse et al., 2015). There were previous studies demonstrated that the effects of low-intensity exercise or mild exercise would be effective in improving physical and cognitive function in healthy older adults (Tse et al., 2015; Butcher et al., 2008). One previous study in the United States of America investigated the effect of mild exercise in older adults with MCI.The previous study showed that the older adults with MCI had improvement in executive function as represented by Mini-Mental State Examination (MMSE) scores and increased performance in Stroop test (Baker et al., 2010). Moreover, the chair-based exercise is one of the types of the mild exercise which promotes functional mobility and balance performance in the older adults. The chair-based exercise is performed primarily in the seated position and contain the components of strengthening exercise, cardiovascular fitness training or endurance training. The previous studies found that the effects of chair-based exercise might improve lower limb strength, balance performance and activities of daily living in the older adults as represented in the timed up and go test and the Barthel indexoutcomes (Cancela Carral et al., 2017, Robinson et al., 2018). Therefore, the mild exercise or the low-intensity exercise in the older adults with MCI is needed.

Cognitive training is a non-pharmacological intervention for delaying progression of MCI-to-Alzheimer's disease (Hakun et al., 2015; Lampit et al., 2014). Previous studies demonstrated that elderly who received the cognitive training as Stroop task training improve the cognitive function. Stroop task is a model for studying cognitive performance including the executive function, selective attention to specific information during decision-making tasks and choosing appropriate responses (Stroop, 1935). The mechanism of neural plasticity that involved Stroop task is the "uses it and improve it" theory (Kleim & Jones, 2008). Moreover, the cognitive training may promote neurogenesis, ability of brain structure and/or function change, or plasticity in individuals with elderly (Aldwin & Gilmer, 2004). Also, previous study demonstrated that cognitive training as Stroop task training lead to a significant reduction in reaction time, error number and increase in data processing speed test in elderly women with MCI. It may reflect the plasticity of old brain making it challenging to learn the new tasks (Fatemeh et al., 2016).

Up-to-date, dual tasks training appear to provide more consistent cognitive or motor function benefits in older adults. There are different types of dual tasks training, such as the combination of cognitive training and motor training, which appear to produce an improvement in memory, balance and mobility in older people (Norouzi et al., 2019; Brustio et al., 2018). Moreover, dual tasks training as combination of mild exercise and cognitive training demonstrated the potential to increase balance ability (Pichierri et al., 2011) and/or improve cognitive functions (Law et al., 2014; Lauenroth et al., 2016) in older adults with MCI. However, some studies investigated effect of dual tasks training on balance performance or cognitive function alone (Pichierri et al., 2011; Law et al., 2014; Lauenroth et al., 2016). Nonetheless, no studies that investigated the effect of dual tasks training on both outcomes that consisted of balance performance and cognitive functions in older adults with MCI (Pichierri et al., 2011; Law et al., 2014; Lauenroth et al., 2016).

As was mentioned, the older adults with MCI had the balance deficits and the balance problem related with the cognitive impairment above. The dual tasks training such as the combination mild exercise and cognitive training might produce the improvement of balance performance and the cognitive functions enhancement. Moreover, it could help to prevent the older adults who had suffering falls due to the cognitive impairment. Therefore, the purpose of this study was to investigate the effects of dual tasks training as combination of mild exercise and cognitive training (ME+CT) on balance performance and cognition functions in older adults with MCI. We hypothesized dual-task training (ME+CT) would improve the balance performance and the cognition function in older adults with MCI, compared with the mild exercise (ME) group or the cognitive training (CT) group.

## Materials and methods

### 1. Participants

Participants were recruited by Watsanawet Social Welfare Development Center Elderly, Phra Nakhon Sri Ayutthaya Province, and local communities in Mueang District, Ubon Ratchathani Province and Dan Khun Thot District, Nakhon Ratchasima Province. They were screened according to the inclusion and exclusion criteria.

The inclusion criteria were: i) Female and male elderly aged 65-89 years with mild cognitive impairment (MMSE scores; uneducated < 14 scores, educated with primary school ≤ 17 scores, educated higher level of primary school ≤ 22 scores) (Institute of Geriatric Medicine, 1999), ii) able to read, iii) able to stand without devices, iv) able to walk with or without devices, v) independent activity daily living, and vi) normal vision and hearing or corrected by medical procedures.

The exclusion criteria were: i) neurological conditions (i.e. cardiovascular disease, Parkinson's disease or psychiatric disease affecting balance performance and communication), ii) cardiovascular disease with no medical treatment (i.e. heart disease, congestive heart failure), iii) high blood pressure > 160/100 mmHg or having the symptoms which were dizziness, faint, nausea, high pulse rate, a lot of sweat at the day of data collecting, and iv) severe pain from musculoskeletal problem (i.e. severe osteoarthritis of knee).

### 2. Study design and procedure

The present study was approved by the Human Research Protection Committee at Rangsit University, Thailand (number RSEC 48/2560) and registered at the Thai Clinical Trials Registry (TCTR20180605002).

The study design was the randomized controlled trial (RCT) with single blinded by assessors. Participants were randomly allocated into 3 groups by simple random sampling; mild exercise (ME) group, cognitive training

(CT) group, or mild exercise with cognitive training group (ME+CT). Random assignment was performed by an unbiased observer not related with the present study by the traditional random picking sealed names of participants and intervention groups from separate containers, to blindly allocate each participant to one of the three groups.

After the participants signed the consent forms, they completed demographic and clinical information including; age, gender, status, education level, occupational, underlying disease. Then, they were asked to evaluate pre-training assessments. Each participant was asked to complete the training program for 45 minutes per session, 12 training sessions within 30 days of the pre-training assessment. The participants performed the post-training assessments once again after the training. The CONSORT flow diagram for the present study is illustrated in Fig. 1.

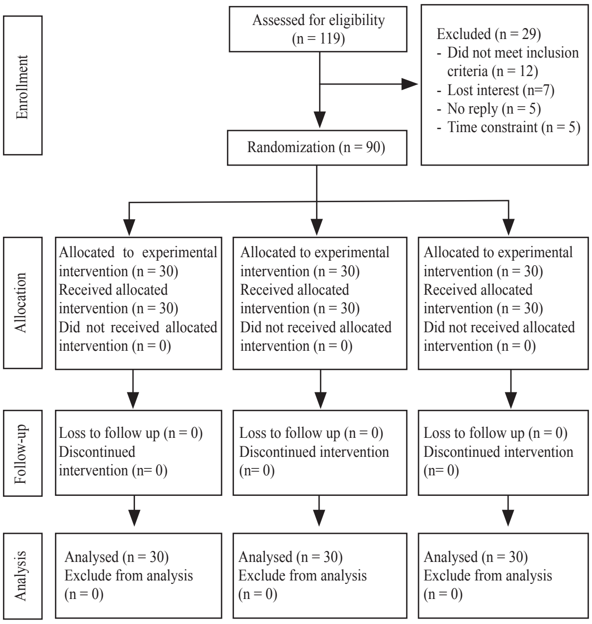


**Fig. 1** CONSORT (Consolidated Standards of Reporting Trials) diagram showing the flow of participants through each stage of study

## 3. Intervention

The three interventions with a maximum of 30 participants per group had a frequency of three sessions per week and a duration of 4 weeks. Each of the 12 sessions lasted 45 minutes (Cancela Carral et al., 2017). Training amount was comparable between the three groups. All interventions were described as follows.

3.1 Mild exercise (ME group)

Participants of the ME group received chair-based exercise which was low-intensity or mild aerobic exercise (intensity = 20-39% of maximal heart rate). The ME consisted of three phases; warm-up 5 minutes, exercise 35 minutes with the rest time as the participant needed, cool down 5 minutes. The warm-up and cool down phases included breathing exercise and passive stretching exercise of upper limbs and lower limbs. The participants were asked to perform exercise in sitting position on the chair with backrest and both feet placed on the floor. The details of exercise phase included chair-based exercise by doing active exercise and progression in each week which were described in Table 1. The exercises were adapted and progressed (the number or sets, the number of repetitions) by the physical therapist to meet the needs of each individual participant to account for the differences between participants (Cancela Carral et al., 2017; Robinson et al., 2018). In the present study, the exercise prescription and the progression of each exercise pose; 10-30 repetitions/set, 3-5 sets per session, 3 days per week, 4 weeks. The progression of exercise is the increased in the number of repetitions per set and the sets per session.

3.2 Cognitive training (CT group)

Participants of the CT group received the Stroop color and word training which based on the Stroop test. The Stroop color and word training in the present study consisted of three tasks as follows; task 1: verbally reading a list of color words (blue, red, green) printed in black ink, task 2: verbally stating the color of a series of Xs printed in blue, red or green ink, and task 3: verbally reading a list of color words that were printed in colored ink (i.e. RED printed in blue ink or RED printed in red ink). The participants underwent the repetitive practice and progressed the training by performing the tasks as quickly as possible that the participants read the corrected color words within shorten time. Each Stroop color and word training task was 15-minutes per task and the rest time between task session for 2-3 minutes.

3.3 Combined mild exercise and cognitive training (ME+CT group)

Participants of the ME+CT group underwent the combined mild exercise and cognitive training at the same time.

All three groups were supervised by three physical therapists who had clinical experience of physical therapy at least two years. They underwent one week of pre-study training to standardize the implementation of the exercise programs. The participants underwent the individually intervention and

**Table 1** Mild exercise and progression based on chair-based exercise

| Exercise pose | Week 1 | Week 2 | Week 3 | Week 4 |
|---|---|---|---|---|
| 1 | Unilateral shoulder flexion | Bilateral shoulder flexion | Alternating shoulder flexion between left side and right side | Combine unilateral full shoulder flexion and elbow extension |
| 2 | Unilateral shoulder abduction | Bilateral shoulder abduction | Bilateral shoulder abduction in oblique axis | Combine bilateral full shoulder flexion and elbow extension |
| 3 | Unilateral elbow flexion-extension | Bilateral elbow flexion-extension | Alternating elbow flex-ion-extension between left side and right side | Combine unilateral shoulder flexion 90 degree and elbow flexion |
| 4 | Unilateral wrist flexion-extension | Bilateral wrist flexion-extension | Alternating wrist flexion-extension between left side and right side | Combine bilateral shoulder flexion 90 degree and elbow flexion |
| 5 | Unilateral finger flexion-extension (opened-closed hand) | Bilateral finger flexion-extension (opened-closed hand) | Alternating finger flexion-extension (opened-closed hand) between left side and right side | Combine unilateral shoulder flexion 90 degree, elbow extension and wrist extension |
| 6 | Unilateral hip flexion (leg elevation with flexed knee) | Bilateral hip flexion (leg elevation with flexed knee) | Alternating hip flexion between left side and right side | Combine bilateral shoulder flexion 90 degree, elbow extension and wrist extension |
| 7 | Unilateral hip abduction (separate one leg, opening and closing in each leg) | Bilateral hip abduction (separate knees, opening and closing legs) | Alternating hip adduction in oblique axis | Combine unilateral knee extension with ankle dorsiflexion |
| 8 | Unilateral knee extension | Bilateral knee extension | Alternating knee extension between left and right legs | Combine bilateral knee extension with ankle dorsiflexion |
| 9 | Unilateral ankle dorsiflexion and plantar flexion | Bilateral ankle dorsiflexion and plantar flexion | Alternating ankle dorsiflexion and plantar flexion between left and right feet | Alternating combined knee extension with ankle dorsiflexion |

**Remark:** Exercise prescription and progression: each exercise pose 10-30 repetitions/set, 3-5 sets per session, 3 days per week, 4 weeks. The progression of exercise is the increased in the numbers of repetition per set and the sets per session.

the progression of training was individually based. The interventions were delivered in three different inclosed sites in three separate local communities in Lak Hok, Mueang Pathum Thani, Pathum Thani province to minimize or prevent experimental contamination effects.

3.4 Outcome measurements

Outcome of measurements in the present study consisted of Mini-Mental State Examination (MMSE) and Mini-Balance Evaluation Systems Test (Mini-BESTest).

The MMSE Thai-2002 version was developed from the MMSE that developed by Marshal F. Folstein and colleague in 1975. It was used to measure thinking ability or cognitive impairment. The MMSE is a 30-point test that measures 5 domains which include: the time and place orientation, short-term memory, attention and solving problems, language, and comprehension and motor skills (Folstein et al., 1975). Three different levels of cognitive functions were classified as followed: severe (score 0-10); moderate (11-20); mild (21-25) (Pernecaky et al., 2006). The Thai version of MMSE was used to measure the cognitive functions in the present study. The content validity, reliability, and specificity of Thai-MMSE were high (Institute of Geriatric Medicine, 1999).

The Thai version of Mini-BESTest examination was used to measure the balance performance in the present study which was developed and translated from original version by Rattanavichit and co-workers in 2020 (Rattanavichit et al., 2020; Franchignoni, et al., 2010). It consisted of four domains; i) anticipatory postural adjustments, ii) reactive Postural Responses, iii) sensory orientation, iv) dynamic balance during gait and cognitive effects. The Mini-BESTest has scored out of 28 points to include 14 items that are scored from 0 to 2 (0: not able to perform, 2: able to perform well). The five different levels of balance performance were determined as followed: very severe deficit (score 0-5); severe deficit (6-11); moderately severe deficit (12-17); moderate deficit (18-23); mild deficit to normal (24-28) (Franchignoni et al., 2015). The cut-off score of the Mini-BESTest was 16 (out of 28) (Yingyongyudha, et al., 2016). Also, the Thai version of Mini-BESTest showed excellent intra-rater reliability (ICC = 0.97-0.98) and inter-rater reliability (ICC = 0.941) (Rattanavichit et al., 2020).

The assessors in the present study were physical therapy interns who underwent measurement training from the primary investigator for 60 hours. The inter-rater reliability in all outcome measures of them was high to excellent (intraclass correlation coefficient (ICC) range=0.88- 0.99).

**4. Data analysis**

Sample size calculation by G*power version 3.1.9.2 was based on a power of 0.80, alpha level of 0.05, and effect size was 0.50. The sample size was calculated based on previously reported the total of 90 person and 30 persons per group (Lipardo & Tsang, 2020).

$$\frac{n}{g} = \frac{\left\{Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right\}^2 \sigma^2}{\delta^2}$$

$$\frac{n}{g} = \frac{\{1.96 + 0.84\}^2 0.61^2}{0.53^2}$$

Statistical analysis was performed using IBM SPSS Statistics 23 for Windows. Data were tested for normal distribution with Kolmogorov–Smirnov tests and homogeneity of variances for between-group comparisons with Levene's tests. For all statistical comparisons, the significance level was set at $\alpha = 0.05$. The groups were analyzed for differences in the baseline demographic and clinical information variables using ANOVAs. The use of multivariate repeated-measures analysis of variance (ANOVA) was initially planned to analyze the group, time, and group–time interaction effects. Post hoc analysis to determine differences in pair- wise group comparisons was performed using Fisher's least significant difference (LSD) test. To compare within-group changes across time for data with normal distribution, the repeated-measures ANOVA with between-group analysis was utilized. For non-normal data, Friedman's ANOVA was applied. Post hoc analysis for time effects was conducted using Fisher's least significant difference (LSD). An intention-to-treat analysis, with the last observation carried forward, might be used for missing data due to dropouts. However, the present study was no drop-out rate, the intention-to-treat was not be analyzed. The *p*-value of $<0.05$ was considered significant for all computations. Utilizing a derived effect size (Cohen's $d = .39$) (Lipardo & Tsang, 2020)

## Results and discussion

One-hundred and nineteen individuals with older adults were screened for enrollment in the present study. Ninety older adults with MCI met the inclusion criteria, and were randomly allocated to the ME, CT and ME+CT groups. No participants reported any adverse side effects after the training, and all 90 participants (100% of compliance) in three groups completed the study and no drop-out rate. The demographic data, clinical characteristics and baseline data for all participants are presented in Table 2. The demographic variables based on gender, age, status, education level and undelying disease were stratified among the ME, CT and ME+CT groups. Thirty participants were allocated in each group. The average age was 69.26 (4.68), 73.43 (7.02), and 70.46 (4.17) years for the ME, CT and ME+CT group respectively. Most of them were female (70% in ME group, 53.33% in CT group and 76.66% in ME+CT group), marriage status (96.67% in ME group, 96.67% in CT group and 93.33% in ME+CT group), graduation from a primary school (73.34% in ME group, 83.33% in CT group and 66.67% in ME+CT group), and having the hypertension as the underlying disease in ME group (33.33%) and CT group (43.34%), but no having underlying disease in ME+CT group (50%). There were no significant differences between three groups in baseline data of the balance performance as represented by Mini-BESTest scores and the cognitive functions as represented by MMSE scores (Table 1, all $p > 0.05$).

**Table 2** Demographic data, clinical characteristics and baseline data (n= 90)

| Variables | All (n = 90) | ME group (n = 30) | CT group (n = 30) | ME+CT group (n = 30) | *p*-value |
|---|---|---|---|---|---|
| Age (years), mean (SD) | 71.05 (5.29) | 69.26 (4.68) | 73.43 (7.02) | 70.46 (4.17) | 0.090 |
| Gender (female), n (%) | 60 (66.67%) | 21 (70.00%) | 16 (53.33%) | 23 (76.66%) | - |
| Status, n (%) | | | | | |
| Single | 4 (4.44%)/ | 1 (3.33%) | 1 (3.33%) | 2 (6.67%) | - |
| Marriage | 86 (95.56%) | 29 (96.67%) | 29 (96.67%) | 28 (93.33%) | |
| Education level, n (%) | | | | | |
| Lower or primary 6 | 67 (74.45%) | 22 (73.34%) | 25 (83.33%) | 20 (66.67%) | |
| Secondary 3 | 19 (21.11%) | 6 (20.00%) | 5 (16.67%) | 8 (26.66%) | |
| Secondary 6 | 2 (2.22%) | - | - | 2 (6.67%) | - |
| Diploma or high vocational certificate | 1 (1.11%) | 1 (3.33%) | - | - | |
| Bachelor Degrees | 1 (1.11%) | 1 (3.33%) | - | - | |
| Underlying diseases, n (%) | | | | | |
| Hypertension | 27 (30.00%) | 10 (33.33%) | 13 (43.34%) | 4 (13.33%) | |
| Diabetes mellitus | 5 (5.56%) | 2 (6.67%) | 1 (3.33%) | 2 (6.67%) | |
| Dyslipidemia | 1 (1.11%) | - | 1 (3.33%) | - | - |
| > 2 underlying diseases | 31(34.44%) | 11 (36.67%) | 11 (36.67%) | 9 (30.00%) | |
| No Underlying disease | 26 (28.89%) | 7 (23.33%) | 4 (13.33%) | 15 (50.00%) | |
| Baseline Mini-BEST scores, mean (SD) | 19.36 (3.62) | 18.13 (3.24) | 18.17 (2.26) | 19.70 (1.54) | 0.215 |
| Baseline MMSE scores, mean (SD) | 18.62 (2.92) | 17.63 (2.37) | 17.60 (1.96) | 18.20 (1.65) | 0.541 |

**Remark:** There was no significant difference in baseline characteristics of participants among three groups; the ME, CT and ME+CT groups.
**Abbreviations:** Mini-BESTest: Mini-Balance Evaluation Systems Test; MMSE: Mini-Mental State Examination; ME group: mild exercise; CT group: cognitive training group; ME+CT group: mild exercise with cognitive training group.

There were significant main effects of group in Mini-BESTest scores ($p$ = 0.003) and MMSE scores ($p$ = 0.037) (ME+CT > CT >ME group, Table 3b, Table 3b. represented in $p$-value[a]). There were also significant main effects of time in Mini-BESTest scores ($p$ = 0.033) and MMSE scores ($p$ = 0.012) (all groups increasing post-training, Table 3b, Table 3b. represented in $p$-value[b]). The mean of Mini-BESTest scores and MMSE scores were significantly increased from the baseline. The mean of Mini-BESTest scores, changed from baseline 18.13 (3.24) to 19.07 (4.11) in ME group, from 18.17 (2.26) to 19.53 (3.15) in CT group, and from 19.70 (1.54) to 21.53 (2.86) in ME+CT group. All mean of Mini-BESTest scores at post-training indicated the moderate level of balance performance. Furthermore, the mean of MMSE scores, by using Thai-2002 version MMSE questionnaire, changed from baseline 17.63 (2.37) to 18.63 (3.11) in ME group, from 17.60 (1.96) to 19.07 (2.97) in CT group, and from 18.20 (1.65) to 20.57 (2.65) in ME+CT group. All mean of MMSE scores after training indicated the moderate level of cognitive function. However, there were no significant interaction effect of time by group in in Mini-BESTest and MMSE scores (Table 3b represented in $p$-value[c]).

**Table 3** Comparison of balance performance and cognitive functions at baseline and post-training in all randomization groups

**(a)** Comparison of balance performance (representing Mini-BESTest scores) and cognitive functions (representing MMSE scores) at baseline and post-training in all randomization groups

| Outcome measures | ME group (n = 30) | | CT group (n = 30) | | ME+CT group (n = 30) | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post |
| Mini-BESTest scores, mean (SD) | 18.13 (3.24) | 19.07 (4.11) | 18.17 (2.26) | 19.53 (3.15) | 19.70 (1.54) | 21.53 (2.86) |
| MMSE scores, mean (SD) | 17.63 (2.37) | 18.63 (3.11) | 17.60 (1.96) | 19.07 (2.94) | 18.20 (1.65) | 20.57 (2.65) |

**(b)** Significance values based on Analysis of Variance for balance performance (representing Mini-BESTest scores) and cognitive functions (representing MMSE scores)

| Outcome measures | p-value[a] | 95%CI[a] | Effect size[d] | p-value[b] | 95%CI[b] | Effect size[d] | p-value[c] | 95%CI[c] | Effect size[d] |
|---|---|---|---|---|---|---|---|---|---|
| Mini-BESTest scores | 0.003** | -4.25 to-0.68 | 0.066 | 0.033* | -3.62 to-0.50 | 0.026 | 0.647 | -1.62 to-3.42 | 0.005 |
| MMSE scores | 0.037* | -3.37 to -0.50 | 0.037 | 0.012* | -4.25 to -0.68 | 0.036 | 0.067 | -0.66 to-3.39 | 0.031 |

**Remark:** [a] p-value : between-groups main effect from two-way mixed ANOVA; [b] $p$ -value : main effect of time from two-way mixed ANOVA; [c] $p$ -value : interaction time by group from two-way mixed ANOVA; * $p$<0.05, ** $p$<0.01, 95% CI: 95% confidence interval; [d] Partial $\chi^2$

**Abbreviations:** Mini-BESTest: Mini-Balance Evaluation Systems Test; MMSE: Mini-Mental State Examination; ME group: mild exercise; CT group: cognitive training group; ME+CT group: mild exercise with cognitive training group

In addition, post-hoc analysis of Mini-BESTest scores and MMSE scores revealed significant differences between CT and ME+CT group, and between ME and ME+CT group (Table 4a). The post-hoc analysis of Mini-BESTest scores and MMSE scores revealed significant differences between baseline and post-training (post-training > baseline, Table 4b)

**Table 4** Significant values of multiple comparisons of Mini-BESTest and MMSE scores by post-hoc analysis

**(a)** between groups by pairwise comparisons (ME vs CT, CT vs ME+CT and ME vs ME+CT)

| Pairwise | Mini-BESTest scores | MMSE scores |
|---|---|---|
| ME vs CT | 0.696 | 0.697 |
| CT vs ME+CT | 0.006* | 0.042* |
| ME vs ME+CT | 0.002* | 0.016* |

**(b)** between timepoints by pairwise comparisons (baseline vs post-training)

| Pairwise | Mini-BESTest scores | MMSE scores |
|---|---|---|
| baseline vs post-training | 0.012* | 0.033* |

**Remark:** Computed by LSD multiple comparisons; *$p$-value <0.05; **$p$-value <0.01

**Abbreviations:** Mini-BESTest: Mini-Balance Evaluation Systems Test; MMSE: Mini-Mental State Examination; ME group: mild exercise; CT group: cognitive training group; ME+CT group: mild exercise with cognitive training group

We investigated the effect of dual tasks training (ME+CT) on balance performance and cognitive functions. To the best of our knowledge, this is the first study to compare the effects of training on both balance performance and cognitive functions as represented by Mini-BESTest scores and MMSE scores among three groups (ME+CT vs. ME vs. CT groups). Overall, all three groups improved in balance performance and cognitive functions after training. Moreover, there were significant differences in balance performance and cognitive functions between ME+CT group vs. CT group, and ME+CT group vs. ME group. Consequently, the dual tasks training as combination of mild exercise with cognitive training induced the improvements in balance performance and cognitive functions in the elderly with MCI.

**1. Effects of mild exercise**

We found that there were significant differences in Mini-BESTest scores between pre- and post-training in ME group.Chair-based exercise may enhance the lower limb strength that is the important component which is the biomechanical constraint in balance control process in the older adults (Cruz et al., 2010). The findings of the present study corresponding with the previous study that determine the effects of low-intensity group exercise on muscle strength and balance of elderly people in the communities (Chompoopan et al.,2019). After participating in the low-intensity exercise, the experimental group had significantly improved in their dynamic balance as represented by performance time in timed up and go test when compared to the control group (Chompoopan et al., 2019). However, we measured the balance performance by using the Mini-BESTest which consisted of static and dynamic balance. The Mini-BESTest include the tasks that divided into four subcomponents: anticipatory postural adjustments, postural responses, sensory orientation, and dynamic gait (Franchignoni et al., 2010). Therefore, the Mini-BESTest scores representing balance performance in the present study involved both static and dynamic postural balance in elderly with MCI.

Furthermore, we found that there were significant differences in MMSE scores between pre- and post-training in ME group. The results of the present study are consistent with the previous study of Baker and colleagues in 2010. The previous study conducted in the elderly with MCI who had similar cut-off of MMSE scores to the present study. They found that there were improvements in cognitive functions as measured by MMSE and Stroop test in the elderly with MCI (Baker et al., 2010). Moreover, the upregulation level of BDNF after mild exercise was found in the previous study (Baker et al., 2010). One possible mechanism could describe that the exercise might be mediated by exercise-induced upregulation level of BDNF (Rasmussen et al., 2009; Whiteman et al., 2014; Leckie et al., 2014). In addition, the mild exercise which were described by the animal studies, activated hippocampal neurons through the glutamatergic pathway and contributed to exercise-induced hippocampal neurogenesis through the androgen receptor (Okamoto et al., 2012; Burns et al., 2010). Thereby, the mild exercise may be relevant for the prevention and slowing down of neurodegenerative diseases, such as Alzheimer's disease (Burns et al., 2010).

**2. Effects of cognitive training**

Also, we found that older adults with MCI in CT group performed increase in Mini-BESTest and MMSE scores after cognitive training as Stroop task training. Stroop tasks involve cognitive performance, especially, the executive function and decision-making tasks (Stroop, 1935). The principle of brain plasticity that support the Stroop task is the "uses it and improve it". The training could induce the specific function of the brain and lead to an enhancement of that specific function (Kleim & Jones, 2008). In addition, the cognitive training may enhance the neural plasticity changes in elderly by promoting the neurogenesis process (Aldwin & Gilmer, 2004). The findings of the present study are corresponding with previous study of Fatemeh and co-workers in 2016. It demonstrated that a significant reduction in reaction time, error number and increase in data processing speed test in elderly women with MCI after Stroop task training (Fatemeh et al., 2016). Even though, the previous study showed only the improvement in term of cognition outcome. Thereby, the cognitive training is one of brain exercise for benefit of slowing down in MCI progression (Hakun et al., 2015).

**3. Effects of the dual tasks training (combination of mild exercise with cognitive training: ME+CT)**

In addition, we discovered that the effects of dual tasks training (ME+CT) could improve cognitive functions and balance performance in the elderly with MCI. The results of the present study are consistency with three previous studies. They demonstrated that the improvements in balance performance (Pichierri et al., 2011) or improving cognitive functions (Law et al., 2014; Lauenroth et al., 2016) after dual tasks training as combination of mild exercise and cognitive training were found in the older adults with MCI. Although, the previous studies measured the effects of dual tasks training on balance performance or cognitive function alone, the present study we investigated the effects of dual tasks training on both balance performance and cognitive functions. Therefore, the dual tasks training could reflect the outcome measure of balance ability and cognitive functions in the older adults with MCI. The dual tasks training as cognitive-motor task training was more beneficial than single-task training alone in improving executive function domain of cognitive functions of elderly persons, and the improvement was not directly due to modulating Aβ metabolism (Yokoyama et al., 2015). It is well known that Aβ peptides are metabolized by the insulin-degrading enzyme that also metabolize insulin (Malito et al., 2008) and that hyperinsulinemia due to peripheral insulin resistance and conditions associated with impaired glucose metabolism, such as obesity, or type 2 diabetes, are linked to cognitive dysfunction and Alzheimer's disease (Smith et al., 2010). Therefore, the dual tasks training as combination of mild exercise and cognitive training can improve the balance ability and cognitive functions in the older adults with MCI.

As mentioned above, the effect of the mild exercise alone, the cognitive training alone, and the combined mild exercise and cognitive training could improve balance performance and cognitive functions. However, the minimally clinically importance differences (MCID) value of MMSE scores > 2 points that indicated the significant improvement in general cognitive outcomes (Huntley et al., 2015). In the present study, the MCID in MMSE scores in the ME+CT group was 2.37 points, while the MCID in MMSE scores in two other groups were less than 2 points. Moreover, the MCID value of Mini-BESTest scores > 3.5 points in patients with balance disorders (Godi et al., 2013). The MCID values Mini-BESTest scores in ME, CT and ME+CT groups were 0.94, 1.36, and 1.83, respectively. The reason that why the findings demonstrated that the MCID values Mini-BESTest scores less than 3.5 points is the Mini-BESTest is the testing which the participants performed static and dynamic balance in standing position. Nonetheless, the participants in the present study underwent the mild exercise as the chair-based exercise in sitting position, and the Stroop color and word training in sitting on the chair with back-rest. Therefore, the evaluations of balance performance in the elderly with MCI may employ more difficulty task conditions like a standing position. It might not reflect the transference of motor learning in the elderly with MCI after undergoing 12-session of training.

There are a few of the limitations of the present study. Firstly, the cognitive training as Stroop task in the present study was used material by the paper within 45 minutes. The participants might not be interesting during research data collections. Further studies would be developed the Stroop task by using applications from computer-based training for being remarkable and attention of participants. Second, the BDNF level that represented neurotrophic factor involving the mild exercise would not measure in the present study. Therefore, the further studies that measured the BDNF level for detecting effect of mild exercise in the elderly with MCI would help to clarify this issue. Finally, the training sessions would not measure the long-term effects of training. It would be interesting to investigate an extended study with follow-up periods to determine whether the immediate effects persisted.

## Conclusion

The researcher suggests that a combination of mild exercise and cognitive training could improve balance performance and cognitive functions in the older adults with MCI as well as the mild exercise alone and the cognitive training alone. Improving functional ability in the elderly with MCI has great potential to benefit not only the elderly with MCI, but also their family or caregivers and spread to ageing health and care systems. In addition, the mild exercise, cognitive training, and a combination of mild exercise and cognitive training as the dual tasks training might help to be delay the progression of MCI to Alzheimer's disease in the older adults. Further research into the role of exercise as an intervention for older adults with dementia is now required, with larger trials over a longer time period which also assess the impact on caregivers, health and well- being of elderly people.

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