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The Benefit of Arm Swing Exercise on Cognitive Performance in Older Women with Mild Cognitive Impairment

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ABSTRACT

Phoemsapthawee J, Ammawat W, Leelayuwat N. The Benefits of Arm Swing Exercise on Cognitive Performance in Older Women with Mild Cognitive Impairment. **JEPonline** 2016;19(6):123-136. The aim of this study was to determine the effects of arm swing exercise (ASE) training on cognitive performance, oxidative stress, lipid profiles, and aerobic capacity in 24 women (65 to 87 yrs of age) with mild cognitive impairment (MCI). After the Mini-Mental State Examination (MMSE), the subjects were randomly allocated to 12 wks of either a 30-min of supervised ASE per day for 5 $d \cdot wk^{-1}$ or a control period followed by a 12-wk washout period. Before and after the period, the MMSE was used to determined cognitive performance, simple reaction times (SRT) and choice reaction time (CRT), and peak oxygen consumption (VO_2 peak). Plasma 8-iso-prostaglandin $F_{2\alpha}$ (8-iso-$PGF_{2\alpha}$) concentration, fasting blood glucose (FBG), and lipid profiles were also determined at rest before and after each period. This study showed improvement in the MMSE score, SRT, and CRT ($P<0.01$) after 12-wk of ASE training when compared to the control period. In the ASE period, 8-iso-$PGF_{2\alpha}$ ($P<0.01$) and FBG concentrations ($P<0.05$) were lower and high-density lipoprotein cholesterol was higher ($P<0.05$)

than in the control period. Moreover, VO_2 peak was improved ($P<0.01$) in the ASE period when compared with the control period. These results show that the ASE training has a beneficial effect on the improvement of cognitive performance through improved oxidative stress, cardiovascular risk factors, and aerobic capacity in older women with MCI.

Key Words: Low-intensity Exercise, VO_2 peak, Reaction Time, Lipid Peroxidation

INTRODUCTION

Mild cognitive impairment (MCI) is identified as a clinical transitional state between the cognitive changes of aging and dementia. The prevalence of MCI is associated with age and rates range from 3% to 15% among older people over 65 yrs of age (14). More than half of older adults with MCI seem to develop dementia within 5 yrs (27,29). It has been established that low aerobic fitness is associated with age-related cognitive decline in older adults with MCI or dementia (11,15,16,36). Moreover, lipid peroxidation seems to have an important role in the development and progression of dementia. Increased levels of isoprostanes (IsoPs) in cerebrospinal fluid, plasma and urine of subjects with MCI, suggested that increased oxidative stress occurs before the onset of symptomatic dementia (18,30). These levels are highly related to the other biomarkers of Alzheimer's disease pathology and the severity of the disease (31). Preventive strategies are required to maintain or enhance cognitive function, and to reduce the incidence of dementia. Interestingly, Alzheimer's Association has addressed that a few non-pharmacological interventions have been tested in randomized controlled trial (RCT), which provide the strongest evidence of whether an intervention is effective for the Alzheimer (1). Therefore, it is critical to explore the potential effects of non-pharmacological interventions to delay or prevent the progression of MCI to dementia.

Although regular exercise has been widely recognized to have a beneficial impact on cognitive function, brain connectivity, and regional brain volume (6,7,13) among older adults and dementia patients (8,19,39), the evidence of benefits of physical exercise in older adults with MCI is obscure and largely unknown (15). Currently, the American College of Sports Medicine recommendations for the elderly suggest at least 150 $min \cdot wk^{-1}$ of moderate exercise or 60 $min \cdot wk^{-1}$ of vigorous-intensity exercise (2). However, due to physiological deterioration and time constraints, many older adults may be unable to accomplish the recommended physical activity levels (40). An alternative lower intensity exercise may be more appropriate for the older adults.

To date, the arm swing exercise (ASE) is recommended by the Thai Health Promotion Fundamental as the means to promoting physical activity (9). An exercise program with all three components (physical, cognitive, and social) conceivably could delay the cognition decline in older adults with cognitive impairment (4). The ASE is an exercise program that accommodates all these requirements. It may be suitable for older adults with MCI because it is a low-intensity activity with simple and gentle movement. It requires no special equipment or clothing. Importantly, a previous study in patients with type 2 diabetes demonstrated that ASE training reduced oxidative stress (23), inflammatory markers, and low-density lipoprotein cholesterol (LDL-C) levels (40) while improving glycemic control (23) and pulmonary function (40). However, there has been no study concerning the effect and mechanism of this

exercise on cognitive performance, oxidative stress, glycemic control, lipid profiles, and aerobic capacity in older women with MCI.

Therefore, the purpose of this study was to investigate the effects of a 12-wk ASE training program on cognitive performance, oxidative stress, glycemic control, lipid profiles, and aerobic capacity in older women with MCI. We hypothesized that the ASE training would improve these parameters in the older women with MCI.

METHODS

Subjects

Twenty-four women (65 to 87 yrs of age) in Nakhon Pathom province of Thailand were recruited. They were considered eligible for the study if they obtained a Mini-Mental State Examination (MMSE) score of ≤23. Exclusion criteria included significant cardiovascular and/or cerebrovascular disease, uncontrolled hypertension and diabetes, musculoskeletal impairment, or the presence of other medical conditions with significant psychiatric or neurologic consequence. The use of statins, antihypertensive, and diabetes medications was permitted. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving humans were approved by the Ethical Review Committee for Research in Human Subjects Ministry of Public Health, Thailand (ref. no 24/2556). Written and verbal informed consents were obtained from all subjects; verbal consent was witnessed and formally recorded.

Power Calculation

The sample size of this study was calculated using the WINPEPI program according to the previous report by Li et al. (24) who reported that 14 wks of Tai Ji Quan training could improve cognitive function and MMSE scores in older adults with cognitive impairment. The decision was made to require 80% power with a significance level of 0.05. Accordingly, the proposed size was 18 subjects per group (including 20% drop out).

Procedures

Baseline Measurements

At the first visit, the subjects received medical examinations including medical history, electrocardiogram (data not shown), and blood sampling for routine blood chemistry and hematology. Anthropometric measurements (height) were also done using a spring-coil measuring tape, which was placed on a flat surface with the backboard supported by the wall. Body composition and mass were measured using a bioimpedance analysis (BIA) device (InBody 720, Biospace, Korea). Blood pressure was measured with an oscillometric semiautomatic device (Visomat OZ, D2, International, Hestia, Germany).

Study Procedure

A randomized controlled trial (RCT) with a crossover design was conducted. Twenty-four women with MCI were recruited. After matching for education years and MMSE score, the subjects were randomly allocated to either an exercise or a control period for 12 wks. After a 12-wk washout period, they crossed over to the other period for 12 more weeks. In addition, they were required to have regular dietary patterns throughout the study period. Demographic data were collected by researchers and medical data were abstracted from records. The subjects' cognitive performance was assessed by using the Thai-adapted version of the

MMSE, simple reaction time (SRT), and choice reaction time (CRT) tests. Aerobic capacity was assessed using an incremental arm peak oxygen consumption (VO_2 peak) test to volitional exhaustion. Blood samples after a 12-hr fast were collected from the antecubital vein to measure plasma 8-iso-$PGF_{2\alpha}$, lipid profiles, and blood glucose (FBG) concentrations. All measurements were performed at the beginning and at the completion of each period.

ASE Intervention

The subjects were asked to perform supervised ASE for 5 $d \cdot wk^{-1}$. The intensity of the ASE is approximately 23% of peak oxygen consumption (VO_2 peak) (23). A warm-up and a cool-down of each period were 5 min of stretching exercise. At the first week of the training, the speed of swinging was 20 $times \cdot min^{-1}$ and progressed to 25 $times \cdot min^{-1}$ during week 4 to week 5 and 30 $times \cdot min^{-1}$ beyond that. Exercise duration was 10 to 15 min for the first three wks and, then, it was increased by 5 min every week until the duration reached 30 min. In starting position of the ASE, each subject stood or sat on a stool. The feet were firmly placed on the ground at shoulder width apart. Subjects were asked to keep their trunk straight with their arms hung naturally. Then, both arms were swung forward about 30° with a smooth and even force and then backward to about 60°. During the ASE, the subjects were informed to maintain their control of breathing and to concentrate their minds on swinging their arm. Before and after the ASE, the Borg rating of perceived exertion (RPE) scale was asked. An exercise trainer monitored adherence and adverse events. All daily physical activity was assessed by self-report or caregiver.

Cognitive Performance

Global Cognitive Function Test

Global cognitive function was assessed with the MMSE by personal face to face interview. It was validated in people aged 60 yrs and older and the optimal cutoff point was defined by different education levels. The sensitivity of the test in illiterate person, 6 yrs of education or lower, and higher than 6 yrs of education was 35.4%, 56.6%, and 92%, respectively. The specificity of the test among these people was 76.8%, 88.9%, and 91.2%, respectively (34). The MMSE is composed of 11 elements that are divided into the following sections: orientation; registration; attention and calculation; and recall and language. A score of 23 or lower is an optimal cutoff point to provide an indication of developing dementia.

SRT and CRT Test

The simple reaction times (SRT) and choice reaction time (CRT) tests were determined using a system whole body reaction measuring equipment (FT-3130, TKK Takei & Company, LTD, Tokyo, Japan). The system comprises a table with three buttons and three light bulbs (red, yellow, and blue). To determine SRT, the subjects respond to the bulb light as it appeared at random intervals in time between 1 and 3 sec by pressing any button with either hand as quickly as possible after a bulb lights up. To determine CRT, the subjects respond to the three possible colored bulbs by pressing a different button (left, middle, right) for each color. Three attempts were allowed per test and the lowest value recorded as the result.

Blood Sampling

At each visit, 6 mL of blood samples were collected from the antecubital vein after a 12-hr fast. One mL of blood was collected into tubes containing fluoride-oxalate for subsequent determination of whole BG. The residual 2 mL into EDTA and 3 mL into clotting tubes; all samples were placed immediately on ice. The tubes were then centrifuged at 4˚C and 3,000

g for 15 min. The upper layer was transferred to a microcentrifuge tube and stored at -80˚C until assay. The serum obtained was used to analyze total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and LDL-C. The plasma obtained was used to analyze the 8-iso-$PGF_{2\alpha}$ concentration.

Blood Chemistry

Plasma 8-iso-$PGF_{2\alpha}$ Concentration

The plasma 8-iso-$PGF_{2\alpha}$ concentration was analyzed using the Acetylcholinesterase Competitive Enzyme Immunoassay Kit (Cayman Chemicals, Ann Arbor, MI, USA) after purification according to the manufacturer's instructions. The samples were assayed in a 96-well plate coated with mouse anti-rabbit IgG monoclonal antibody to 8-iso-$PGF_{2\alpha}$. This assay is based on the completion between 8-iso-$PGF_{2\alpha}$ and an 8-isoprostane-acetylcholinesterase (AChE) conjugate for a limited number of 8-isoprostane-specific rabbit antiserum binding sites. The rabbit antiserum-8-iso-$PGF_{2\alpha}$ complex binds to the rabbit IgG mouse monoclonal antibody that has been previously attached to the well. This plate was washed to eliminate the unbound tracer and, then, the Ellman's Reagent was added. The plates were read using a UV spectrophotometer, 96-well microplate reader (Multiscan EX; Thermo Labsystems Oy, Vantaa, Finland) at wavelength 405 nm. The value of concentration was calculated by the equation obtained from the standard curve plot. The range of the standard curve was from 0.82 to 500 $pg \cdot mL^{-1}$. The data were expressed in $pg \cdot mL^{-1}$.

FBG and Serum Lipid Profiles

Whole BG was measured using a photometric measuring unit (Yellow Springs Instrument Analyzer, YSI, 2300 STAT Plus) according to glucose oxidase methods. Serum TC, TG, HDL-C, and LDL-C were measured using the standard automated laboratory methods (Roche Integra 800, Roche, Basel, Switzerland). These parameters were analyzed by the Medical Pathology Group, Nakhon Pathom Hospital, Thailand.

Aerobic Capacity

Subjects performed incremental arm exercise test on an arm crank ergometer (Ergoselect 400; ergoline GmbH, Bitz, Germany) while sitting in a chair. After a 2-min rest measurement, the test was started at 10 watts and the work rate was increased every minute by 3 watts. The subjects were encouraged to sustain the test at 60 to 70 $rev \cdot min^{-1}$ until exhaustion of which the subjects then completed an unloaded recovery period of 3 min. In this study, we considered the highest attained oxygen consumption value. Expired gas samples were collected breath-by-breath basis using an Oxycon Mobile portable metabolic system (Erich Jaeger, Viasys Healthcare, Germany). VO_2, carbon dioxide production (VCO_2), and HR were recorded throughout the test. The system was calibrated before each test using a 3-L syringe and known concentrations of oxygen (15% O_2) and carbon dioxide (5% CO_2). Oxygen saturations were continuously monitored with a pulse oximeter. Heart rate recovery (HRR) was calculated as the difference between the peak exercise HR and the post-exercise HR at 1 min (HRR1min) and 2 min (HRR2min).

Statistical Analyses

Data analyses were performed using SPSS statistics. Measurement outcomes are expressed as mean ± SD. The normal distribution of all data was investigated using the Shapiro-Wilk test. Statistical comparisons of dependent variables were analyzed by a two-way ANOVA

with repeated measures (subject factors of exercise and time). The Bonferroni method was used to adjust the multiple comparisons. A P value of <0.05 was considered to be significantly different.

RESULTS

Twenty-four older women (65 to 87 yrs of age) with MCI completed the study. The mean score of MMSE was 18.7 ± 4.0. Most of the subjects were married and had low level of education. The rates of hypertension, diabetes mellitus, dyslipidemia, and osteoarthritis were 54.2%, 41.2%, 33.3%, and 8.3%, respectively. In the ASE period, subjects attended 95.6% of their supervised exercise sessions. The subjects met their prescribed duration and intensity of 95.6% and 89.2%, respectively. Less than 10% of subjects reported regular exercise outside the study. The characteristic data of the subjects in control and ASE periods are shown in Table 1. In the ASE period, body mass (BM) (P<0.05), resting HR (P<0.01), systolic blood pressure (SBP) (P<0.01), and mean arterial pressure (MAP) (P<0.01) were significantly decreased with respect to the baseline values; whereas, the control period showed no significant change in any variables. Body mass (P<0.05), resting HR (P<0.01), SBP (P<0.01), and MAP were significantly decreased in the ASE period when compared to the control period (P<0.01). The periods did not differ significantly for body mass index, percentage of body fat (%BF), fat mass, skeletal muscle mass, waist to hip circumference ratio, and diastolic blood pressure (Table 1).

Table 1. Characteristic Data of Subjects in the Control and ASE Periods.

	Control		ASE	
	Baseline	**Post-Test**	**Baseline**	**Post-Test**
Body Mass (kg)	53.6 ± 13.1	53.6 ± 13.2	53.7 ± 13.2	53.0 ± 12.7$^{*\,\#}$
Height (cm)	159.0 ± 5.4	159.0 ± 5.4	159.0 ± 5.4	159.0 ± 5.4
BMI ($kg \cdot m^{-2}$)	24.5 ± 1.0	24.5 ± 1.0	25.1 ± 0.8	24.2 ± 0.9$^{\#}$
Body Fat (%)	40.2 ± 6.8	40.4 ± 6.8	39.9 ± 6.9	37.7 ± 7.2
Fat Mass (kg)	23.0 ± 7.5	23.2 ± 7.5	22.9 ± 7.5	22.3 ± 7.0$^{\#\#}$
SMM (kg)	16.9 ± 1.9	16.9 ± 2.0	16.9 ± 2.0	17.1 ± 1.9
W/H Ratio	1.02 ± 0.03	1.02 ± 0.03	1.02 ± 0.04	1.01 ± 0.02
HR ($beats \cdot min^{-1}$)	81.4 ± 10.8	82.3 ± 9.7	81.5 ± 13.1	77.4 ± 9.0$^{**\,\#\#}$
SBP (mmHg)	147.0 ± 18.7	146.5 ± 19.1	148.5 ± 22.3	132.5 ± 6.2$^{**\,\#\#}$
DBP (mmHg)	78.9 ± 7.5	77.1 ± 12.0	76.2 ± 12.9	74.6 ± 7.6
MAP (mmHg)	101.6 ± 10.5	100.3 ± 13.4	100.3 ± 14.6	93.9 ± 6.4$^{*\,\#\#}$

Data are expressed as mean ± SD; **N** = 24; **ASE** = Arm Swing Exercise; **BMI** = Body Mass Index; **SMM** = Skeletal Muscle Mass; **W/H** = Waist to Hip Circumference; **SBP** = Systolic Blood Pressure; **DBP** = Diastolic Blood Pressure; **MAP** = Mean Arterial Pressure. Significantly different from baseline within period; *P<0.05, **P<0.01; Significant difference (adjusted by its baseline) between periods; $^{\#}$P<0.05, $^{\#\#}$P<0.01

Cognitive Performance

In the ASE period, the MMSE score, SRT, and CRT were significantly increased (P<0.01) with respect to the baseline, but they were unchanged in the control period (Table 2). All of the three variables were significantly improved (P<0.01) in the ASE period when compared with the control period (Table 2).

Table 2. Cognitive Performance of Subjects in the Control and ASE Periods.

	Control		ASE	
	Baseline	Post-Test	Baseline	Post-Test
MMSE Score	19.5 ± 4.7	19.1 ± 4.8	18.8 ± 4.0	20.9 ± 5.1** ##
SRT (sec)	0.60 ± 0.16	0.58 ± 0.14	0.59 ± 0.16	0.50 ± 0.14** ##
CRT (sec)	0.67 ± 0.14	0.67 ± 0.13	0.68 ± 0.15	0.61 ± 0.13** ##

Data are expressed as mean ± SD; **N** = 24; **ASE** = Arm Swing Exercise; **MMSE** = Mini-Metal State Examination; **SRT** = Simple Reaction Time; **CRT** = Choice Reaction Time. Significantly different from baseline within period; **P<0.01; Significant difference (adjusted by its baseline) between periods; ##P<0.01.

Blood Chemistry

Plasma 8-iso-PGF$_{2\alpha}$ Concentration

In the ASE period, plasma 8-iso-PGF$_{2\alpha}$ concentration was significantly decreased (P<0.01) with respect to the baseline, but it was unchanged in the control period (Figure 1). Plasma 8-iso-PGF$_{2\alpha}$ concentration was significantly decreased (P<0.01) in the ASE period when compared with the control period (Figure 1).

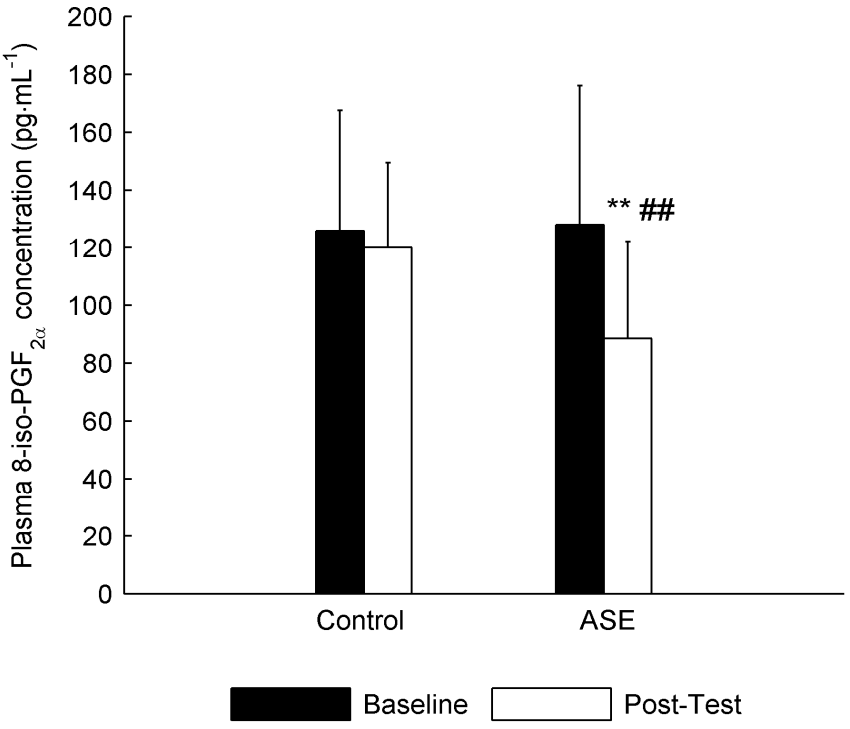

Figure 1. Plasma 8-iso-PGF$_{2\alpha}$ Concentration of Baseline and Post-Test in Control and ASE Periods. Values are expressed as mean ± SD; **N** = 24; **ASE** = Arm Swing Exercise. Significantly different from baseline within period; **P<0.01; Significant difference (adjusted by its baseline) between periods; ##P<0.01

FBG and Lipid Profiles

The FBG concentration in the ASE period was significantly decreased (P<0.05) when compared with the control period. Serum TC, TG LDL-C, TG/HDL-C, and LDL-C/HDL-C were not significant between periods (Table 3). In the ASE period, serum TC, TG/HDL-C, LDL-

C/HDL-C, and FBG (P<0.01) were significantly decreased with respect to the baseline. The control period showed no significant changes in these variables (Table 3). Serum HDL-C concentration in the ASE period was significantly increased (P<0.05) when compared with the control period.

Table 3. FBG and Lipid Profiles of Subjects in the Control and ASE Periods.

	Control		ASE	
	Baseline	Post-Test	Baseline	Post-Test
FBG ($mg \cdot dL^{-1}$)	118.8 ± 15.3	121.7 ± 17.0	122.6 ± 18.6	106.6 ± 12.8** ##
TG ($mg \cdot dL^{-1}$)	136.3 ± 54.1	137.9 ± 64.4	140.5 ± 65.8	119.7 ± 49.1
HDL-C ($mg \cdot dL^{-1}$)	60.2 ± 15.8	60.9 ± 15.7	62.1 ± 16.3	72.2 ± 15.4** #
LDL-C ($mg \cdot dL^{-1}$)	123.3 ± 40.5	123.9 ± 56.6	129.8 ± 53.9	112.8 ± 35.7
TG/HDL-C	2.5 ± 1.3	2.6 ± 1.9	2.5 ± 1.3	1.8 ± 0.9**
LDL-C/HDL-C	2.1 ± 0.9	2.3 ± 1.7	2.2 ± 0.6	1.6 ± 0.6**

Data are expressed as mean ± SD; **N** = 24; **ASE** = Arm Swing Exercise; **TC** = Total Cholesterol; **TG** = Triglyceride; **HDL-C** = High Density Lipoprotein Cholesterol; **LDL-C** = Low Density Lipoprotein Cholesterol; **FBG** = Fasting Blood Glucose. Significantly different from baseline within period; *P<0.05, **P<0.01; Significant difference (adjusted by its baseline) between periods; #P<0.05, ##P<0.01

Aerobic Capacity

In the ASE period, the VO_2 peak (P<0.01), HRR1min (P<0.05), and HRR2min (P<0.05) were increased with respect to the baseline. The control period showed no significant changes in these variables (Table 4). VO_2 peak (P<0.01) in the ASE period was significantly increased when compared with the control period. HR max, HRR1min and HRR2min, and RPE were not significantly different between periods (Table 4).

Table 4. Aerobic Capacity of Subjects in the Control and ASE Periods.

	Control		ASE	
	Baseline	Post-Test	Baseline	Post-Test
$\dot{V}O_2$ peak ($mL \cdot kg^{-1} \cdot mim^{-1}$)	11.1 ± 1.4	10.9 ± 1.7	11.1 ± 1.5	12.2 ± 1.9** ##
HR max ($beats \cdot min^{-1}$)	137.3 ± 7.5	137.0 ± 8.0	136.3 ± 9.0	138.8 ± 6.9
HRR1min (beats)	13.0 ± 3.2	13.8 ± 2.2	13.3 ± 1.5	14.5 ± 1.9*
HRR2min (beats)	27.7 ± 3.1	27.6 ± 3.1	27.0 ± 2.7	28.6 ± 3.3*
RPE	18.2 ± 1.5	18.0 ± 1.8	17.9 ± 1.9	17.9 ± 1.8

Data are expressed as mean ± SD; **N** = 24; **ASE** = Arm Swing Exercise; **VO_2 peak** = Peak Oxygen Consumption; **HR** = Heart Rate; **HRR1min** = Heart Rate Recovery at 1 min; **HRR2min** = Heart Rate Recovery at 2 min; **RPE** = Rating of Perceived Exertion. Significantly different from baseline within period; *P<0.05, **P<0.01; Significant difference (adjusted by its baseline) between periods; #P<0.05, ##P<0.01

DISCUSSION

This is the first study to reveal the beneficial effects of ASE training in older women with MCI. The results demonstrate that ASE training causes a significant improvement in the subjects' cognitive performance, aerobic capacity, and oxidative stress.

The findings of this study support the hypothesis that ASE training has a beneficial effect on cognitive performance in older women with MCI. The results may be explained by many mechanisms that include improved oxidative stress, hemodynamics, lipid profiles, and the

subject's VO_2 peak. First, it is important to emphasize that an exercise program that engages the subjects' physical, cognitive, and social components is helpful in preventing cognitive decline in older adults (4). The ASE is such an exercise program. It accommodates all these requirements. Physically, it is safe, simple, and gentle to perform. It is appropriate for different levels of mobility, and it can be performed while standing or sitting. During the ASE training, the subjects learned to control their breathing. They also learned the power in cultivating the perception of experiencing tranquility and awareness. Finally, ASE provides sociocultural interactions when practiced in a group setting. The group-based ASE exhibits an interface with the sociocultural dimension, directly influencing self-esteem and confidence, which usually results in less chance of social isolation (12,20). Sociocultural interactions promoted by ASE may explain the expansion of networks and social contact, enhancing the potential for language and cognitive function (12,20,44). The improvement in MMSE score (0.6 points), SRT (9.5% faster) and CRT (SRT 4.5% faster) in older women with MCI in this study is consistent with previous studies showing that physical activity is associated with delayed cognitive impairment (15,22,38,43). The impact of ASE training on MMSE in this study is similar to those of Tai Chi training (4,24).

Another mechanism that should be considered is the improved oxidative stress after 12 wks of ASE training, which is supported by the previous findings in patients with type 2 diabetes (23,40). Of note, high plasma 8-IsoPGF$_{2\alpha}$ concentrations have been detected in individuals with MCI, suggesting that increased oxidative stress occurs before the onset of symptomatic dementia (18). Interestingly, several previous studies (3,32,35) also reported the potential effect of physical exercise on improved oxidative stress in brain by up-regulating some antioxidant enzyme activities (superoxide dismutase, glutathione peroxidase) in the older adults' brain. Exercise-induced modulation of ROS levels plays an important role in the protein content and expression of brain-derived neurotrophic factor and its physiological function, resulting in better function and increased neurogenesis (32,34,35). Therefore, the ASE training may have high impact on cognitive performance through reduced lipid peroxidation levels and improved oxidative balance, which might help delay or prevent the progression of MCI to dementia.

Alternatively, the increased cognitive performance as a result of ASE training may be due to a reduction of cardiovascular risk factors (such as hemodynamics, glycemic control, and lipid profiles). For example, regarding hemodynamics, previous studies (10,21) have indicate that elevated BP is associated with cognitive impairment in later life. The impairment of glucose metabolism is also associated with dementia (21). Low levels of HDL-C are associated with hippocampus volume and dementia (42). Elevated cardiovascular risk factors are associated with poorer brain function in older adults (26). Importantly, the ASE training may have a high impact on cognitive function through improvement in cardiovascular risk factors. The results are supported by many previous studies that indicate regular low-intensity aerobic exercise could lead to positive benefits, such as a reduction in glycated haemoglobin levels (23,40), LDL-C, %BF (40), and BP (17).

Finally, it is also reported that an increase in aerobic capacity (VO_2 peak) allows for an improvement in the resting cerebral blood flow and oxygen transportation in the brain, which may offset the age-related decline in cognitive function (5,11). The neuroadrenergic hypothesis suggests that increased aerobic capacity results in changes in neurotransmitter availability (noradrenaline, adrenaline, and serotonin) to the cerebral environment. These

specific neurotransmitters are associated with memory storage and retrieval that provide benefits to cognitive performance (11,45). Moreover, other studies (6,7,13) have consistently shown that increased aerobic capacity is associated with changes in cerebral structure and brain-derived neurotrophic factor, which enhance neurogenesis in the brain. Again, this is important because it clear that a regular low-intensity physical activity contributes to the maintenance of aerobic fitness, better health, and well-being in the older adults (25,28).

A limitation of this study is that the discussion is only on the basis of the improvement of oxidative stress, cardiovascular risk factors, and aerobic capacity. Thus, we will gain more benefits if further research examines the effects of the ASE on other mechanisms, such as brain-derived neurotrophic factor, antioxidants, and neurodegeneration. In addition, more research is necessary to investigate the effects of ASE on the specific types of cognition deficit in older adults and other neurodegenerative diseases (including but not limited to Parkinsonism and Alzheimer diseases).

CONCLUSION

This study suggests a beneficial effect of ASE training on improving cognitive performance in older women with MCI. It is likely that the improvement of cognitive performance is due to improved intellectual stimulation and social interaction, oxidative stress, cardiovascular risk factors, and aerobic capacity. More precise mechanisms are needed to be clarified.

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