COMPARISON OF HOME-BASED AEROBIC VS. HOME-BASED RESISTANCE EXERCISE IN OLDER PERSONS WITH MILD COGNITIVE IMPAIRMENT

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COMPARISON OF HOME-BASED AEROBIC VS. HOME-BASED RESISTANCE EXERCISE IN OLDER PERSONS WITH MILD COGNITIVE IMPAIRMENT

KITSANA KROOTNARK

A Dissertation Submitted in Partial Fulfillment of the Requirements

for the Degree of DOCTOR OF PHILOSOPHY

(Physical Therapy)

Faculty of Physical Therapy, Srinakharinwirot University

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THE DISSERTATION TITLED

COMPARISON OF HOME-BASED AEROBIC VS. HOME-BASED RESISTANCE EXERCISE IN OLDER PERSONS WITH MILD COGNITIVE IMPAIRMENT

BY

KITSANA KROOTNARK

HAS BEEN APPROVED BY THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY IN PHYSICAL THERAPY AT SRINAKHARINWIROT UNIVERSITY

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Title	COMPARISON OF HOME-BASED AEROBIC VS. HOME-BASED RESISTANCE EXERCISE IN OLDER PERSONS WITH MILD COGNITIVE IMPAIRMENT
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Objective: to investigate the effect of home-based exercise on various domains of cognitive function and physical performance in persons with MCI, by comparing three groups: aerobic exercise, resistance exercise and control group. *Methods:* This study was a single-blind randomized controlled trial. Ninety eligible participants, aged 60-80 years were randomly assigned to one of 30 people from three categories: aerobic exercise, resistance exercise or control group. The aerobic and resistance exercise groups received three months of home-based exercise (35 minutes/day including warm up and cool down, five days/week, and increased by five minutes every two weeks). The control group was asked to perform their usual daily activities. The Montreal Cognitive Assessment (Thai version) (MoCA), Trail making test part A and B (TMT-A, TMT-B), Stroop color and word test (SCWT), a Digit span test (DST), a Stick design test (SDT), a Timed up and go test with manual task (TUG-M), a 6-minute walk test (6MWT) and a 30-second chair stand test were collected before training and after one, two and three months of training and a three-month follow-up. *Results:* Both aerobic and resistance groups showed significant improvements in all outcome measures during three-month post-training and follow-up, except SDT, while there was no cognitive improvement in control group at post-training and follow-up. When compared to the control group, aerobic group had significant improvements in MoCA, TMT-A, TMT-B and SCWT, while resistance group had significant improvements in MoCA and TMT-B at post-training and follow-up. However, there were no differences in any outcome measures between aerobic and resistance groups, except SCWT and 6MWT, which was significantly greater in the aerobic group than in the resistance group post-training. Additionally, both the aerobic and resistance groups had the earliest significant improvement on the MoCA, SCWT and TUG-M two months after training. *Conclusion:* Home-based exercise at low intensity, whether aerobic or resistance training, was effective for improving cognitive function in older persons with MCI and had sustained effects until follow-up.

Keyword : Elderly, Home exercise, Executive function, Attention, Memory

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CHAPTER 1
INTRODUCTION

Background

Thai society has advanced to ageing society because the elderly population has continuously increased. In 2014, the population aged 60 years and over was 9.9 million or about 15% of the total population (1) and this population group is likely to increase to 27.8 million by 2050 (2). When we get older, deterioration of the body in various systems, such as cardiopulmonary system, neurological system, musculoskeletal system, visual and auditory system is evident (3). Such deterioration and vulnerability of the body systems could lead to several health problems found in the elderly. One of the common health problems found in the elderly is dementia. The number of dementia population worldwide in 2013 was estimated at 44.35 million, reaching 75.62 million in 2030 and 135.46 million in 2050 (4). In Thailand, it was reported that the number of people with dementia was estimated at 600,000 people in 2015 and this number will be doubled in 2030 (5). Dementia is considered as a neurocognitive disorder (NCDs) in DSM-5; its definition is “a progressive cognitive decline in one or more domains of cognition: perceptual-motor function, executive function, complex attention, learning and memory, language, or social cognition and interfere with normal everyday activities independently” (6). This neurocognitive disorder can be screened in the clinical practice using 2 common scales; Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA). Dementia is one of the health problems leading to physical disability and dependence among the elderly, resulting in a burden of family members and caregivers. Moreover, dementia extensively affects the social and economic costs in terms of medical and social care (7). Therefore, early detection of dementia may delay the adverse impact of dementia in older individuals, their family and society.

Mild neurocognitive disorder or mild cognitive impairment (MCI) is the mild form of dementia and this disorder can later progress to be dementia. A study of the prevalence of mild cognitive impairment in different geographical regions which

analyzed data from USA, Europe, Asia and Australia found that the estimation of mild cognitive impairment prevalence was ranged from 5.0 – 36.7% (8). In Thailand, the prevalence of mild cognitive impairment in elderly ranged from 22.7 – 71.4% (9-11), based on the demographic and assessment tools used in data collection. Mild cognitive impairment is a condition which the function of the brain becomes impaired in one or more cognitive domains (6). With this condition, the elderly have decreased cognition or noticed a decrease in their performance on cognitive task, but these symptoms do not interfere with basic activities of daily living (12). Mild cognitive impairment can be classified into four categories: amnestic MCI single, amnestic MCI multiple, non-amnestic MCI single and non-amnestic MCI multiple (12, 13). To prevent further dementia, there are guidelines for the care of dementia in each country. These guidelines provide information about risk and protective factors for dementia and offer strategies for maintaining the optimal cognitive function or reducing the risks which include diet, alcohol intake, smoking, depression, cognitive stimulation, physical and social activities. For example, UK guideline recommends joining in the cognitive stimulation group (14) and Australian guideline encourages the elderly to take part in social activities and mental stimulation that can be considered as a protective factor for dementia (15).

Prevention and treatment of cognitive impairment in the elderly has increased their importance. The evidence from systematic reviews of cognitive training in older people with mild cognitive impairment showed that cognitive training was effective in enhancing various domains of cognitive function, especially memory, executive function and attention domains which are measured using Wechsler Memory Scale (WMS), Stroop Color and Word Test (SCWT), Digit Span Test (DST) and Trail Making Test (TMT) (16, 17). Cognitive training is one of cognition-focused interventions that commonly used in the prevention of cognitive impairment. The cognition-focused interventions can be divided into three types: cognitive stimulation, cognitive training and cognitive rehabilitation (18). Cognitive stimulation focuses on activities that stimulate the overall functions of the brain that causes changes in some domains of cognition through daily

life or social interaction such as art therapy, music therapy or social activity (18). Cognitive training is designed to stimulate specific brain abilities, such as attention, memory, executive function, or perceptual-motor function individually based on the objectives of each study (18-20) which were found to be effective in people with mild cognitive impairment (17, 21). Cognitive rehabilitation focuses on individual disability rather than only cognitive impairment. This intervention mainly uses in people with dementia and aims to improve everyday life performance that is very beneficial to the patients (18, 22). Studies comparing the benefit of cognitive stimulation and cognitive training showed that cognitive training improved cognitive performance better than cognitive stimulation in people with cognitive decline (23, 24). A systematic review evaluating the effectiveness of cognitive rehabilitation and cognitive training showed no difference in cognitive outcomes between the two interventions (22). Therefore, among 3 types of cognition-focus intervention, cognitive training is more preferable and widely used in clinical practice.

In addition to cognitive training, physical exercise is also used to prevent cognitive impairment. Systematic reviews revealed that physical exercise, especially aerobic exercise, has been shown to benefit global cognitive function (as measured by Mini-Mental State Examination; MMSE) in patients with mild cognitive impairment but it is unclear in which specific domain of cognition was improved from physical exercise (25, 26). In general, exercises are classified into four basic types: aerobic exercise, resistance (strengthening) exercise, flexibility exercise and balance (27, 28). According to literature reviews, most of the exercises that are popular for improving cognitive function are aerobic, resistance or multimodal exercises (25, 26, 29, 30). The multimodal exercise is exercise program that consists of several types of exercises, mostly aerobic and resistance exercises.

Aerobic exercise is one of the most common methods of training to improve cognitive function. From reviews, the aerobic exercise program used for this purpose is often given in the form of walking with treadmill and cycling (25, 26, 31). The advantage of these two types of exercise is due to the fact that the intensity of exercise can be

easily controlled and adjusted as needed, but treadmill walking and cycling require specific exercise equipment that may result in limited access of the elderly. Another aerobic exercise program is the group exercise under supervision of the trainer (25, 32-34). Apart from the safety benefit, the group exercise intensity can be adjusted to suit the ability of the elderly. However, the group exercise may not be appropriate for those elderly who could not travel to join the group (35). Therefore, home-based exercise is another interesting option for exercise to reduce these afore-mentioned limitations.

Resistance training is also introduced to enhance cognitive performance. According to the systematic reviews, resistance exercise had positive effects on global cognitive function, executive function and short-term memory domains in older adults (36, 37). There are some studies showed the effect of resistance training at moderate intensity, twice a week for 3 months in promoting better global cognitive function in older adults with mild cognitive impairment compared to the control group (38, 39). However, systematic reviews of the effect of exercise on cognitive function in older adults with mild cognitive impairment included all types of exercises (40-42). Although there was a systematic review on aerobic and resistance exercises for cognitive function improvement in mild cognitive impairment elderly, the study did not compare the effect of each type of exercise (43). Therefore, it is unclear whether aerobic or resistance exercises have a greater effect on cognitive function in older adults with mild cognitive impairment. This information is necessary for planning specific and effective exercise training to improve cognitive function in older adults with mild cognitive impairment. Moreover, the findings will be helpful for identifying an alternative exercise for improving cognitive function in those who have limitations or restriction on either aerobic or resistance exercises.

Based on the above review, the home-based exercise is another intervention of choice to prevent the progression of dementia in elderly with mild cognitive impairment. Home-based exercise refers to an exercise performed within or around the home (44). This type of exercise is considered safe to perform without supervision, does not require any exercise equipment or simply use the equipment that can be found at home.

However, the questions remain as which home-base exercise would be appropriate to implement in elderly with mild cognitive impairment. According to the American College of Sports Medicine and the American Heart Association recommendations (28), the elderly should do aerobic exercise regularly at the moderate intensity, 30 minutes/day, 5 days/week and do muscle strength training at 10-15 repetitions of 8-10 exercises at least 2 days/week to maintain physical fitness and preserve independence of daily life. World Health Organization (WHO) also recommended that the elderly should do physical activity to reduce the risk of cognitive decline (45). At present, there are studies on home-based exercise in the elderly and patients with Alzheimer's disease, with the results focused on functional performance outcome (46, 47). For people with mild cognitive impairment, there are studies on home-based or community-based exercise with multimodal exercise and the results focused only on functional performance outcome (48, 49). However, there is no evidence that any type of home-based exercise can help older people with mild cognitive impairment to enhance cognitive function. In addition, both of aerobic exercise and resistance exercise were found to be effective in improving cognitive function but there are limited studies comparing aerobic exercise and resistance exercise in elderly with mild cognitive impairment.

Research questions

1. What was the effect of home-based aerobic exercise and home-based resistance exercise on the various cognitive domains and physical functions in older persons with mild cognitive impairment?

2. Which home-based exercise, aerobic or resistance exercise, was better in improving cognitive and physical functions in older persons with mild cognitive impairment?

3. When to detect the earliest effect of home-based aerobic exercise and home-based resistance exercise on cognitive and physical functions in older persons with mild cognitive impairment?

Objectives of the study

There were three main objectives of the study.

1. To evaluate the effect of home-based aerobic exercise and home-based resistance exercise on the various cognitive domains and physical functions in older persons with mild cognitive impairment.

2. To compare the effect among home-based aerobic exercise, home-based resistance exercise and those without exercise on older persons with mild cognitive impairment.

3. To evaluate the earliest time of changes in cognitive and physical functions as a result of home-based aerobic exercise and home-based resistance exercise in elderly persons with mild cognitive impairment.

Scope of the study

The study focused on the effect of home-based aerobic exercise and home-based resistance exercise as compared to those who do not exercise on the various cognitive domains and physical functions in older persons (aged 60 years old and over) with mild cognitive impairment both amnestic and non-amnestic type. The outcome measures were cognitive functions in memory, executive function, attention and perceptual-motor function domains by using Stroop Color and Word Test (SCWT), Digit Span Test (DST), Trail Making Test (TMT) and Stick Design Test (SDT) and physical functions by using Timed Up and Go Test (TUG), 6-minute walk test (6MWT) and 30-second chair stand test. All measurements were conducted before and after 1, 2 and 3 months of exercise and follow-up 3 months after the end of the exercise program.

Hypotheses of the study

1. Cognitive function would be significantly improved in older persons with mild cognitive impairment who were trained with home-based aerobic exercise and home-based resistance exercise.

2. Older persons with mild cognitive impairment in the exercise group would demonstrate better cognitive function as compared to those in the control group.

3. Older persons with mild cognitive impairment in home-based aerobic exercise would demonstrate better cognitive and physical functions improvement compared to those in home-based resistance exercise.

4. Cognitive function would be significantly improved in older persons with mild cognitive impairment at 1 month after training in home-based aerobic exercise and home-based resistance exercise.

Benefit of the study

The study would provide evidence about the benefit of home-based aerobic exercise and home-based resistance exercise on cognitive and physical functions in older persons with mild cognitive impairment. If the study found the effectiveness of which home-based exercise, it would be another choice of exercise that does not require exercise equipment or use exercise equipment found at home for older persons with mild cognitive impairment to improve cognitive and physical functions. In addition, the findings from this study would be used for planning specific and effective exercise training to improve cognitive function in older adults with mild cognitive impairment and would be used for identifying an alternative exercise for improving cognitive function in those who have limitations or restriction on either aerobic or resistance exercises.

CHAPTER 2
REVIEW OF LITERATURE

The advancement of healthcare and medical technology has resulted in better health and longer life. While the birth rate decreases, the proportion of the elderly population has increased. The definition of the elderly varied from country to country and still did not have a specific age cut-off. However, the United Nations specified numbers for both 60 and 65 years of age in their statistical presentation of the elderly (50). In Thailand, the elderly are individuals aged 60 years and over and have Thai nationality (1). Currently, Thailand is classified as aging society and approaching completely aged society and super-aged society in the near future. By the end of 2019, the number of Thai elderly population was 11.1 million people or about 16.7% of the total population (51) and the number of this population group is expected to increase to 27.8 million by 2050 (2). In older age, the body underwent more degenerative changes in various body systems, such as cardiopulmonary system, neurological system, musculoskeletal system, visual and auditory system (3, 52). The deteriorating performance of the functions of these body systems could lead to several health problems found in the elderly. Dementia is one of the common health problems found in the elderly.

Dementia

Dementia is classified as a major neurocognitive disorder in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5); its diagnostic criteria are

1. There is evidence of progressive cognitive decline in one or more domains of cognitive function: perceptual-motor function, executive function, complex attention, learning and memory, language or social cognition based on self-reported cognitive complaint or the clinician and documented by standardized neuropsychological test that there has been a significant decline in cognitive function.

2. The cognitive deficits interfere with independent of activities of daily living.

3. The cognitive deficits do not occur in the context of a delirium.

4. The cognitive deficits are not explained by other mental disorders (6).

Dementia is a progressive neurocognitive disorder that affects mostly the elderly, including Thai people (53). The number of dementia population worldwide in 2013 was estimated at 44.35 million, reaching 75.62 million in 2030 and 135.46 million in 2050 (4). In Thailand, it was reported that the number of people with dementia was estimated at 600,000 people in 2015, reaching 1.12 million in 2030 and 2.08 million in 2050 (5). Dementia is a major health problem which leads to physical disability and mortality in the elderly (53). Older people with dementia need to be cared for by their family members and caregivers, resulting in physical, emotional and financial stress of the caregivers (5). Moreover, dementia also has a wide impact on social and economic costs in terms of medical and social care (7). Therefore, early detection of dementia may delay the adverse impact of dementia in older individuals, their family and society.

Types of cognitive function and their clinical measurement

Types of cognitive function

Cognitive function refers to the ability to process information and generate appropriate responses through learning, thinking, problem solving, and decision making (54). Cognitive function can be classified into 6 categories (6), as following;

1. **Perceptual-motor function**

Perceptual-motor function includes visual perception, visuoconstructional reasoning and perceptual-motor coordination (6). The impairment of perceptual-motor function may lead to requiring more effort to work with perceptual-motor tasks, for example depending on others for traveling (55).

2. **Executive function**

Executive function includes planning, decision-making, working memory, responding to feedback, inhibitory control and cognitive flexibility (6). The executive function refers to a top-down cognitive process that is required when you

need to concentrate and pay attention, when performing automatic tasks or relying on your instinct. It takes time to think before doing, faces the unexpected challenges and resists the attractions (56).

3. Complex attention

Complex attention includes the ability to maintain attention over a long period of time (sustained attention), the ability to pay attention on more than one stimulus at the same time (divided attention), the ability to focus on certain stimuli while ignore other distracting stimulus (selective attention) (57), and the ability to identify, integrate and respond to the information that one receives (processing speed) (58).

4. Learning and memory

Learning and memory include free recall, cued recall, recognition memory, long-term memory and implicit learning (6). Memory can be divided into two major types: short-term memory and long-term memory. Long-term memory is also divided into two subtypes that are 1) the explicit memory (or declarative, or conscious memory) and 2) the implicit memory (or non-declarative, or unconscious memory) (59).

5. Language

Language includes speaking, listening and the ability of language usage. Examples of language start from the ability to name of objects, the ability to find of words, the ability to use language fluency, the ability to use correct grammar and syntax and the ability to receive the messages of others (6, 55).

6. Social cognition

Social cognition includes recognition of emotions and theory of mind (6). The recognition of emotions is the ability to recognize the people's emotions from their facial expressions and the theory of mind refers to the ability to understand people's thoughts or ability to predict people's experiences (55).

Clinical measurements of cognitive function

Assessment of cognitive function is important in screening and diagnosing mild cognitive impairment or dementia. It can also be used to monitor the progression of cognitive decline. These assessment scales are standardized tests for global cognition. The most popular standardized test for mild cognitive impairment screening and

diagnosis are Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA).

1. **Mini-Mental State Examination (MMSE)**

The Mini-Mental State Examination (MMSE) is the well-known, most widely translated and used for screening cognitive function. The scores are ranging from 0 to 30 points, with lower scores associated with higher cognitive impairment. The cut-off score at less than 24 points indicates cognitive impairment (60). In Thailand, the Mini-Mental State Examination: Thai version (MMSE – Thai 2002) was translated and developed by Institute of Geriatric Medicine, Department of Medical Services, Ministry of Public Health. The scores of this measurement also range from 0 to 30 points, as the original Mini-Mental State Examination but this measurement classifies people into three groups according to educational level. The cut-off scores used to indicate cognitive impairment in people with higher than primary school and primary school education are less than 23 and 18, respectively. Only people without education, the scores are ranging from 0 to 23 points and the cut-off score is less than 15 (55).

2. **Montreal Cognitive Assessment (MoCA)**

The Montreal Cognitive Assessment (MoCA) is developed to detect for mild cognitive impairment. The scores are the same range as Mini-Mental State Examination but the cut-off score that is used to indicate cognitive impairment is less than 25 points (60, 61). In the Thai version, it has the same description and interpretation as the original version. Thai version of the Montreal Cognitive Assessment show good internal consistency, high sensitivity (72.1%) and specificity (75.0%) for detecting people with mild cognitive impairment (62). Moreover, Montreal Cognitive Assessment demonstrated superiority over Mini-Mental State Examination for detecting mild cognitive impairment (63, 64).

In addition to global cognition assessment, there are clinical scales for assessing specific cognitive domains for differential diagnosis of each type of dementia, for example, patients with Alzheimer's disease suffer from loss of cognition in learning and memory domain more than other cognitive domains. Assessment of cognition in

each domain reveals the specific impairment of cognition for planning appropriate and corresponding treatment. Clinical scales that are commonly used for evaluating specific domain of cognition (65, 66) are shown in Table 1.

Table 1 Cognitive domains and their clinical scales

Clinical measurement	Subdomains	Number of studies	Measurement method	Psychometric properties
Executive function				
Trail Making Test - B (67-69)	Cognitive flexibility	32	- Part B: Line alternating between numbers and letters. - Score based on the time of the completed task.	- There are reports of normative data separated by age and education level and cut-off scores for each part . - Inter-rater reliability (r = 0.90) - Test-retest reliability (r = 0.44-0.89)
Stroop Color Word Test (70, 71)	Cognitive inhibition, selective attention	12	- 1) read the word (name of the color), 2) name the color and 3) name the color of words within 45 seconds/task. - Score based on the number of the correct items.	- There are reports of normative data separated by age and education level. - Test-retest reliability (r = 0.67-0.83)

Table 1 Cognitive domains and their clinical scales (cont')

Clinical measurement	Subdomains	Number of studies	Measurement method	Psychometric properties
Executive function				
Digit Span Test (72)	Working memory, short-term auditory memory	12	- Repeat the given set of numbers both forward and backward. - Score based on the length of the set of numbers.	- Internal consistency (r = 0.67-0.95) - Test-retest reliability (r = 0.41-0.83)
Attention				
Trail Making Test - A (67-69)	Selective and divided attention	26	- Part A: Line connecting the numbers in order from 1 to 25 - Score based on the time of the completed task.	- There are reports of normative data separated by age and education level and cut-off scores for each part. - Inter-rater reliability (r = 0.94) - Test-retest reliability (r = 0.36-0.79)

Table 1 Cognitive domains and their clinical scales (cont')

Clinical measurement	Subdomains	Number of studies	Measurement method	Psychometric properties
Attention				
Digit Symbol Substitution test (73, 74)	Processing speed	6	- Write the correct symbol in the space below the given number. (The numbers and symbols shown as an example.) - Score based on the number of the correct items.	- This task is part of the Wechsler Adult Intelligence Scale. - There are reports of normative data. - Psychometric properties are reported as an overall of the Wechsler Adult Intelligence Scale.
Learning and memory				
Logical memory (75)	Immediate and delayed recall	15	- Tell the story that the assessor tells you immediately and after 30 minutes. - Score based on the number of the correct recalled items.	- This task is part of the Wechsler Memory Scale. - Psychometric properties are reported as an overall of the Wechsler Memory Scale.

Table 1 Cognitive domains and their clinical scales (cont')

Clinical measurement	Subdomains	Number of studies	Measurement method	Psychometric properties
Learning and memory				
Digit Span Test (forward) (72)	Short-term auditory memory	4	- Repeat the given set of numbers. - Score based on the length of the set of numbers.	- Internal consistency (r = 0.67-0.95) - Test-retest reliability (r = 0.41-0.83)
Perceptual-motor function				
Clock drawing test (76, 77)	Visuospatial and praxis abilities, planning	9	- Draw a watch face, complete the numbers and draw clock hands pointing to the specified time. - Score based on the number of the correct drawn items.	- Inter-rater reliability (r = 0.82-0.94) - Test-retest reliability (r = 0.70-0.94) - Sensitivity = 77% and specificity = 87% in screening for moderate to severe cognitive impairment

Table 1 Cognitive domains and their clinical scales (cont')

Clinical measurement	Subdomains	Number of studies	Measurement method	Psychometric properties
Perceptual-motor function				
Clock reading test (78)	Visual perception	Not report	- Read the time shown in the watch face image without numbers (only the hands) with each image showing a different time. - Score based on the number of telling the time correctly.	- Sensitivity = 82% and specificity = 70% at cut-off ≤ 10.5 in screening for Alzheimer's disease - Construct validity (r = 0.50) compared to Rey figure copying
Stick design test (79, 80)	Visuoconstructional reasoning	Not report	- Arrange the matches according to the example shown. - Score based on the number of the correct placed matches.	- Sensitivity = 58% and specificity = 90% in screening for dementia - Construct validity (r = 0.544) compared to Clock drawing test

Table 1 Cognitive domains and their clinical scales (cont')

Clinical measurement	Subdomains	Number of studies	Measurement method	Psychometric properties
Language				
Verbal fluency (81-83)	Language fluency, cognitive flexibility	34	- Tell words beginning with a given letter (letter fluency) or tell words in a given category (category fluency) or tell words in two different categories (switching verbal fluency) as many as possible within 1 minute/task. - Score based on the number of the correct items.	- There are reports of normative data separated by age and education level. - Internal consistency (r = 0.83) - Inter-rater reliability (r = 0.99) - Test-retest reliability (r = 0.70) (from Controlled Oral Word Association Test) - Switching verbal fluency: construct validity (r = 0.445) compared to Trail Making Test

Table 1 Cognitive domains and their clinical scales (cont')

Clinical measurement	Subdomains	Number of studies	Measurement method	Psychometric properties
Language				
Boston Naming Test (84, 85)	Verbal naming	22	- Tell the name of the given picture. - Score based on the number of the correct items.	- There are reports of normative data separated by age and education level. - Test-retest reliability (r = 0.91)
Token test (86)	Verbal comprehension	3	- Follow the given instructions referring to images of different colors, shapes and sizes. - Score based on the number of the correct items.	- Good validity and reliability

Mild cognitive impairment

Definition of mild cognitive impairment

Mild neurocognitive disorder or mild cognitive impairment (MCI) is a term used to describe the stage between normal cognitive function and dementia and the elderly with mild cognitive impairment have a high rate of progression to dementia (87). There are four criteria of DSM-5 for diagnosis of mild cognitive impairment (6), as following;

1. There is evidence of cognitive decline in one or more cognitive domains (executive function, complex attention, learning and memory, perceptual-motor function, language or social cognition) based on self-reported cognitive complaint and documented by standardized neuropsychological test.
2. The cognitive deficits do not interfere with independent of activities of daily living.
3. The cognitive deficits do not occur in the context of a delirium.
4. The cognitive deficits are not explained by other mental disorders.

Prevalence of mild cognitive impairment

Systematic review of 35 studies in participants aged over 60 years revealed that the prevalence of mild cognitive impairment in different geographical regions was ranged from 0.5 – 41.8% and the pooled prevalence of mild cognitive impairment was 17.3% (95% confidence interval (CI) = 13.8 – 20.8) (88). In Thailand, although several researchers collected the prevalence of people with mild cognitive impairment but there was no report on the prevalence of cognitive impairment in the whole country. However, the prevalence of cognitive impairment in elderly people aged 60 years and over was ranged from 22.7 – 71.4% in rural area (9, 10). A study of people worked at the Ramathibodi Hospital aged between 50 and 60 years showed those with a mild cognitive impairment of 30.8% (11), which can be seen as different by demographic and assessment tools used to collect data.

Risk factors of cognitive decline

There were studies on the risk factors affecting cognitive decline that could be divided into 2 main areas: non-modifiable and modifiable risk factors. Non-modifiable

risk factors include genetic, age, gender and race (45, 89). Increasing age is the strongest risk factor for cognitive decline, dementia, particularly for Alzheimer disease (90). The meta-analysis of mild cognitive impairment incidence per 1,000 person-years for ages 75-79 years, 80-84 years and ≥ 85 years were approximately 22.5, 40.9 and 60.1, respectively (91). Currently, several studies had shown a relationship between the development of cognitive impairment and dementia with education (92) and medical conditions, such as hypertension, diabetes, obesity, hearing loss and depression (93-100). Furthermore, lifestyle-related risk factors were associated with an increased risk of developing mild cognitive impairment and dementia, including physical inactivity, smoking, alcohol use and social isolation (101-104). These were classified as modifiable risk factors which focused on the application to prevent dementia and/or the delay of progression of cognitive decline. Less education, hearing loss and air pollution were the most modifiable risk factors that can contribute to increase dementia risk in early life, midlife and later life, respectively (105) as summarized in Table 2.

Table 2 Modifiable risk factors for dementia

Modifiable risk factors	Age range	Prevalence	Weighted PAF
Less education	Early life (age < 45 years)	40.0%	7.1%
Hearing loss	Midlife (age 45 - 65 years)	31.7%	8.2%
Traumatic brain injury		12.1%	3.4%
Hypertension		8.9%	1.9%
Alcohol (> 21 units/week)		11.8%	0.8%
Obesity (BMI ≥ 30)		3.4%	0.7%
Smoking	Later life (age > 65 years)	27.4%	5.2%
Depression		13.2%	3.9%
Social isolation		11.0%	3.5%
Physical inactivity		17.7%	1.6%
Diabetes		6.4%	1.1%
Air pollution		75.0%	2.3%

Weighted PAF = Weighted population attributable fraction

Classification of mild cognitive impairment

Mild cognitive impairment can be classified into two major types that is amnestic MCI and non-amnestic MCI based on memory domain. Amnestic MCI is characterized by clinical presentation with memory impairment while non-amnestic MCI has normal memory but presence of impairment at least one domain in non-memory cognitive domains such as executive function, attention, perceptual-motor function and language domains (87). In addition, both types of mild cognitive impairment can separate in a single cognitive domain or multiple cognitive domains that the number of affected domains may be due to brain disease or pathology and severity of disease. Moreover, multiple cognitive domains may have a higher chance of progression from mild cognitive impairment to dementia than a single cognitive domain (12, 87). However,

all types of mild cognitive impairment can advance to dementia, with the amnestic MCI progresses to Alzheimer dementia and non-amnestic MCI progresses to vascular dementia or lewy body dementia (non-Alzheimer dementia) (12).

Management of cognitive impairment

Pharmacological treatment

Currently, there is no evidence for the efficacy of acceptable pharmacological treatment in the mild cognitive impairment, so pharmacology is mainly used to reduce risk factors for cognitive deficit and dementia, such as taking antihypertensive drugs, cholesterol-lowering drugs and vitamins. Moreover, the specialized medical care should focus on the treatable causes of cognitive impairment and re-evaluation of cognitive function to assess the progression of the cognitive decline (13, 106).

Non-phamacological treatment

Non-pharmacological treatments are other therapies that did not use medicines for improving the cognitive functions, such as cognitive training, physical activity intervention, and lifestyle modification (107). There is a recommendation of these treatments may be effective in reducing the progression from cognitive decline (45).

1. **Transcranial direct current stimulation**

Transcranial direct current stimulation (tDCS) is a noninvasive brain stimulation that regulates the cortical excitability in a polarity-dependent form and can induce neuronal activity (108). It is currently being used in the treatment of neurological disease such as stroke. There was a study of the effect of tDCS in mild cognitive impairment found that anodal tDCS over the right dorsolateral prefrontal cortex improved cognitive function in attention and visual memory domain (109).

2. **Cognitive-focused interventions**

Cognition-focused interventions are the strategies used to enhance or maintain cognitive function in people who suffer from cognitive impairment. The cognition-focused interventions can be divided into three categories (18), as following;

2.1 Cognitive stimulation

Cognitive stimulation refers to a wide range and non-specific approach of activities that aimed at stimulating the people to improve cognitive functions through daily life or social interaction like puzzles, word games, indoor gardening, art therapy or music therapy. It focuses on the involvement of multiple cognitive domains rather than the targeting at a specific cognitive domain (18, 110).

2.2 Cognitive training

Cognitive training is a cognitive practice training that enhances performance of cognitive function, which targets at a specific cognitive domain. Repetitive cognitive training will lead to improve in the cognitive domain being trained. Cognitive training is usually organized on an individual basis depending on the cognitive problems of the person and is often modified or increased the difficulty of the task when the trained person does better (18, 110). For example, the participant listens or reads a section of text and then answers questions about it. Difficulty of the questions can range from general to concrete details and data. This cognitive training can be practiced using traditional pen-and-pencil or computer-based program (111).

2.3 Cognitive rehabilitation

Cognitive rehabilitation is a more individualized practice method for helping people with cognitive impairments. It focuses on the management of functional disability rather than cognitive function alone. For example, training on an important function of daily activities using action-based learning by creating a model and then the participants learn and follow. There may be included the modification of participant's environment and surroundings (22). This type of intervention is therefore used in people with mild to moderate dementia and is intended to improve their performance in daily life, which is of great benefit to the patient (18).

There were studies comparing the benefit of cognitive stimulation and cognitive training in older people at risk of cognitive decline and mild Alzheimer's disease and they showed that cognitive stimulation was less effective to improve cognitive performance than cognitive training (23, 24). Another systematic review evaluating the effectiveness of cognitive rehabilitation showed that cognitive

rehabilitation was a valuable treatment for supporting the management of everyday activities in people with mild to moderate dementia and their families (22). Moreover, there were evidence of cognitive training in older people with mild cognitive impairment that suggested cognitive training was effective in improving cognitive functions at least one domain and reducing the risk of cognitive decline and dementia (16, 17, 45).

The effect of cognitive training on cognitive function generally involves both compensation and restoration mechanisms (112). The compensation mechanism activated other areas of the brain or other networks to compensate for the impaired part (112). There was an increase of brain activation after memory training within a large network of the frontal, temporal, and parietal areas, especially in the right inferior parietal lobule that related the memory in participants with mild cognitive impairment (113). The restoration mechanisms activated at the networks or the impaired brain areas to restore the cognitive performance (112). There were studies reported that cognitive training, especially mnemonic strategy training, improved memory by restoring partial activation in the hippocampus of participants with mild cognitive impairment (114, 115).

3. Physical exercise

Physical exercise is a subset of physical activity that involves any movements of body produced by skeletal muscles and results in energy expenditure. Exercise is a planned, structured and repetitive activity that is intended to improve or maintain one or more components of physical fitness (116). Exercises are generally divided into four basic types: aerobic exercise, resistance exercise, flexibility exercise and balance (27, 28).

3.1 Aerobic exercise

Aerobic exercise or endurance exercise is an activity that promotes or improves physical fitness, cardiovascular endurance, respiratory, and circulatory system. The recommendation of aerobic exercise in the elderly is to perform moderate intensity aerobic physical activity for at least 30 minutes on 5 days each week. For example, the aerobic physical activities are walking, jogging, and swimming (28).

3.2 Resistance exercise

Resistance exercise or strengthening exercise is an activity that maintains or increases muscle tone and muscle strength using weight or resistance. The recommendation of resistance exercise in the elderly is to perform 8-10 resistance exercise involving the major muscle groups (such as chest muscles, arm and shoulder muscles, abdominal and back muscles, leg and buttock muscles, etc.) for at least 2 days per week. For example, the muscle strengthening activities are lifting weight or a resistance band or using their own body weight (28).

3.3 Flexibility exercise

Flexibility exercise or stretching exercise is an activity that maintains or increases the flexibility of muscle for regular activity and daily life. The recommendation of flexibility exercise in the elderly is to perform this activity at least 2 days per week. For example, the flexibility activities are stretching, yoga and pilates (28).

3.4 Balance exercise

Balance exercise is an activity that increases postural balance and reduces risk for falls, which is common problem in the elderly. The recommendation of balance exercise in the elderly is to perform balance exercises at least 2 days per week especially older people who are at risk of falling. For example, the balance activities are balance training and Tai-Chi (28).

According to systematic reviews, physical exercise was beneficial for cognitive function, mainly global cognition, in participants with mild cognitive impairment (25, 26). The physical exercises used for improving cognitive function can be categorized into three groups: aerobic exercise, resistance exercise and multimodal exercise (consisted of aerobic exercise, resistance exercise, balance exercise and/or flexibility exercise). From meta-analyses, the effect of exercise on global cognition is largely attributed to a multimodal training program with shorter session duration and higher frequency which had a greater impact on cognitive function in persons with mild cognitive impairment (25, 117). Exercising in short session may lead to less fatigue, which can have a positive effect on the movement ability and motivation to exercise,

whereas high frequency exercise may maintain levels of exercise-induced neurological factors, which resulted in improving neurological health (117).

The effect of physical exercise on cognitive function is due to the physiological mechanisms of neuroprotective and neuroplastic effects on brain structures (30, 118). Brain-derived neurotrophic factor (BDNF) is one of neurotrophic factors that plays a role in enhancing neuronal development and stimulating the activity of neurons in the brain (119). BDNF levels decreased with increasing age and were associated with the loss of gray matter at hippocampus affecting memory deficit in the elderly (120). Exercise had resulted in an increased release of BDNF which positively effect on cognitive function (118). A Study had shown that people who exercise regularly affect BDNF concentration and found that BDNF release increased 2-3 times during exercise (121). Moreover, there is a study shown that 3 months of aerobic exercise had increased the resting of BDNF level by almost four times (122). In addition to releasing neurotrophic factors such as BDNF, exercise also improved cerebral blood flow and reduced systematic inflammation that may help to prevent age-related cognitive decline (118).

In addition to aerobic exercise, resistance exercise was also beneficial for cognitive function in healthy older adults and participants with mild cognitive impairment. From systematic reviews and meta-analyses, resistance exercise significantly improved global cognitive function and executive function domain in both healthy older adults and participants with mild cognitive impairment and improved short-term memory as assessed by the digit span test in healthy older adults (36, 37). The resistance exercises that improve cognitive function can be accomplished by focusing on the lower limbs and both the upper and lower body (39, 123-125). It was also found that tri-weekly of resistance exercise had a significant benefit to global cognitive function and biweekly in executive function in older adults (36).

The effect of resistance exercise on cognitive function is due to the physiological mechanisms of neuroprotective and neuroplastic effects on brain structures. Insulin-like growth factor-1 (IGF-1) is one of the most important neurotrophic

factors for growth and development in humans and have been associated with brain especially cognitive function (126). Studies in older adults demonstrated that low levels of serum IGF-1 were associated with poor cognitive function, especially a decrease of information processing speed (127). Resistance exercise caused changes in brain function by increasing serum IGF-1 levels (128) and elevating circulating BDNF (129). A Study had found that there was an approximately 20% increase in circulating IGF-I in people who performed 13 weeks of resistance exercise at 60-70% of 1 repetition maximum (RM) (130).

Aerobic exercise at least 30 minutes per day for 3 to 6 months or resistance exercise at moderate to high intensity, 2-3 days per week for at least 3 months had been shown to improve cognitive function and physical performance in the elderly and participants with mild cognitive impairment. Summary of program of training, intensity, duration and outcomes of exercises are shown in Table 3.

Table 3 Program of training, intensity, duration and outcomes of exercises

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Physical exercise						
Vaughan S., et al . 2014 (34)	49 elderly	68.9 ± 3.3	Exp: Multimodal class included cardiovascular, strength and motor fitness training (balance, coordination, flexibility and agility) Con: Usual activities	Not report	60 minutes/day 2 days/week 16 weeks	Cog: executive function (TMT, COAS, COWA) Phy: TUG, 6MWT, SLS Others: plasma BDNF
Maki Y., et al. 2012 (131)	150 elderly	72.0 ± 4.0	Exp: Walk on a regular basis and increase their steps per day gradually. Con: Educational lectures that were not directly related to prevent mental decline.	Not report	90 minutes/day 1 day/week 12 weeks	Cog: global cognitive function (The 5-Cog), executive function (TMT) and attention (DSST, YKSST) Phy: grip strength, walking speed, balance, TUG Others: QOL, GDS, TMIG-IC, LSA
Lautenschlager NT., et al. 2008 (132)	170 MCI	98.7 ± 8.6	Exp: Individualized home-based physical activity program such as walking, strength training exercise, circuit gym exercise, etc. depending on each participant to choose Con: Usual care	Moderate	150 minutes/week 24 weeks	Cog: global cognitive function (ADAS-Cog) Others: BDI, MCS

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Physical exercise						
Kemoun G., et al. 2010 (133)	31 dementia	81.8 ± 5.3	Exp: Physical stimulation based on walking exercises, equilibrium and endurance Con: Did not practice any physical activities.	Mild to moderate	60 minutes/day 3 day/week 15 weeks	Cog: global cognitive function (French ERFC) Phy: gait parameters (walking speed, stride length, double limb support time)
Yang SY., et al. 2015 (134)	50 AD	72.0 ± 7.0	Exp: Cycling training Con: Health education	Moderate	40 minutes/day 3 days/week 12 weeks	Cog: global cognitive function (MMSE, ADAS-Cog) Others: NPI, QOL-AD
Coetsee C., Terblanche E. 2017 (135)	67 elderly	62.8 ± 5.7	Exp1: Resistance training using machines and free weights, 3 sets of 10 repetitions Exp2: Treadmill walking at 70-75% of HRmax, 47 minutes Exp3: 4 Intervals of 4 minutes treadmill walking at 90-95% of HRmax interspersed by 3 minutes active recovery at 70% HRmax Con: Did not exercise.	Moderate	16 weeks	Cog: executive function (computerized Stroop task) Phy: TUG, submaximal Bruce treadmill tests

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Physical exercise						
Biazus-Sehn LF., et al. 2020 (40)	MCI	71.8 ± 6.0	Exp: Aerobic, multimodal, others Con: Not report	Not report	40 - 45 minutes/week	Cog: global cognitive function, cognitive speed, verbal fluency, immediate and delayed recall, working memory, executive function and attention
Cai Y., et al. 2015 (136)	MCI	70 - 78	Exp: Aerobic, multimodal, walking Con: Usual daily activity, stretching, balance and/or toning, non-exercise, active cognitive training, low-intensity placebo physical activity, recreational activities	Moderate	20 - 90 minutes/day, 1 - 4 days/week, 10 - 52 weeks	Cog: global cognitive function, executive function, memory, attention and processing speed
Sanders LMJ., et al. 2019 (117)	elderly, MCI	> 50	Exp: Aerobic, anaerobic, multicomponent, psychomotor Con: No exercise, stretching, balance and tone	Moderate	30 - 90 minutes/day, 1 - 5 days/week, 4 - 52 weeks	Cog: global cognitive function, executive function and memory

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Physical exercise						
Gates N., et al. 2013 (31)	MCI	65 - 95 (mean =76)	Exp: Aerobic, multimodal, resistance, walking Con: Education or no treatment	Moderate	30 - 90 minutes/day, 2 - 4 days/week, 6 - 52 weeks	Cog: global cognitive function, executive function, memory and information processing
Ohman H., et al. 2014 (26)	MCI, Dementia	68 - 86	Exp: Multimodal, walking, Tai Chi, ergocycling, strength training Con: Usual daily activity, stretching, education, placebo physical activity	Not report	30 - 90 minutes/day, 2 - 4 days/week, 6 - 52 weeks	Cog: global cognitive function, executive function, attention, memory and communication
Law CK., et al. 2020 (41)	MCI, Dementia	68 - 86	Exp: Aerobic, multimodal, resistance, walking Con: Not report	Moderate	total training duration of > 24 hours	Cog: global cognitive function, executive function, reasoning, memory, attention and language

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Physical exercise						
Demurtas J., et al. 2020 (42)	MCI	Not report	Exp: Aerobic, mind-body, mixed physical activity, resistance Con: Not report	Not report	mean frequency 1 - 3.8 times/week, mean duration 36.6 - 146 minutes	Cog: global cognitive function, attention, executive function, memory, motor speed, and language Phy: gait speed, chair stand, balance, aerobic capacity, strength Others: health related QOL
Resistance exercise only						
Kimura K., et al. 2010 (137)	119 elderly	≥ 65	Exp: Facility-based program using progressive resistance training and balance training Con: Health education	60% of 1-RM	2 (3) sets of 10 repetitions 90 minutes/day 2 days/week 12 weeks	Cog: executive function (task switching test) Others: SF-36 questionnaire

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Resistance exercise only						
Cassilhas RC., et al. 2007 (138)	62 elderly	65 - 75	Exp: 6 resistance exercises on specific equipment (chest press, leg press, vertical traction, abdominal crunch, leg curl, and lower back) Con: Stretching	50% and 80% of 1-RM	2 sets of 8 repetitions 1 hour/session 3 days/week 24 weeks	Cog: working memory (DST), short-term memory (WMS-R), attention (Toulouse-Pieron's concentration attention test) and long-term memory (Rey-Osterrieth complex figure) Phy: body composition, 1-RM test Others: SF-36 questionnaire, GDS, POMS, hemodynamic measures, blood viscosity, erythrocytes and hematocrits and IGF-1
Smolarek AC., et al. 2016 (125)	37 elderly	65.87 ± 5.69	Exp: 5 lower body and 5 upper body exercises using resistance machines and dumbbells Con: No exercise intervention	60 - 70% of 1-RM	3 sets of 10 repetitions 3 days/week 12 weeks	Cog: global cognitive function (MoCA) Phy: upper and lower limb strength, flexibility and anthropometric parameters

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Resistance exercise only						
Coelho-Junior HJ., et al. 2020 (139)	36 elderly	≥ 60	Exp1: Resistance exercise using exercise machines and free weight Exp2: Resistance exercise using elastic bands (perform concentric contractions as fast as possible) Con: No exercise intervention	Moderate to high	3 sets of 12 - 15 repetitions 2 days/week 22 weeks	Cog: global cognitive function (MMSE), short-term memory (picture memory test) Phy: TUG with cognitive task Others: GDS, serum levels of BDNF
Yoon DH., et al. 2018 (124)	45 cognitive frailty	73.9 ± 4.3	Exp: High-speed resistance exercise using elastic exercise band Con: Continue routine daily activities and perform static and dynamic stretching using elastic exercise band.	Depend on color of the elastic exercise band	12 - 15 repetitions 1 hour/session 3 days/week 16 weeks	Cog: global cognitive function (MMSE-Korean, CERAD-Korean), memory (Rey 15-item Memory test), processing speed and cognitive flexibility (TMT), working memory (DST), executive function (FAB) Phy: SPPB, TUG, isokinetic dynamometer Others: Frailty score

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Resistance exercise only						
Mavros Y., et al. 2017 (140)	100 MCI	> 55	Exp1: High-intensity progressive resistance exercise (PRT) Epx2: Computer-based multidomain of cognitive training Exp3: High-intensity PRT and computer-based multidomain of cognitive training Con: Watching general documentary videos, stretching	80 - 92% of 1-RM	60 - 100 minutes/day 2 - 3 days/week 24 weeks	Cog: global cognitive function (ADAS-Cog), executive function (WAIS-III, COWA), memory (BVRT, Logical memory I, II), and processing speed and attention (SDMT) Phy: VO2peak, muscle strength Others: Frailty score
Hong SG., et al. 2018 (38)	47 MCI	75.53 ± 4.48	Exp: Resistance exercises with an elastic band Con: Maintain current lifestyle.	65% of 1-RM	1 hour/session 2 days/week 12 weeks	Cog: executive function (COWA, Stroop test), attention and working memory (DST) and memory (Rey 15-item Memory test) Phy: senior fitness test, body composition Others: electroencephalograms

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Resistance exercise only						
Mollinedo Cardalda I., et al. 2019 (39)	77 MCI	84.8 ± 7.9	Exp1: Resistance exercise focused on the lower limbs using resistance elastic bands Epx2: Physical exercise focused on the lower limbs and aimed at increasing the range of mobility and coordination Con: Crafts, reading comprehension and cognitive stimulation activities	Not report	2 - 3 sets of 10 - 15 repetitions 1 hour/session 2 days/week 12 weeks	Cog: global cognitive function (MMSE, Pfeiffer test) Phy: five times sit-to-stand test, balance, Barthel index Others: SF-12
Lee J. 2020 (43)	MCI	> 50	Exp: Aerobic, multimodal, resistance, walking, jogging, shadowboxing, Tai Chi Con: Usual care, education, normal social activities, stretching, balance and tone	Moderate to vigorous	60 minutes/day 3 days/week 25 weeks	Cog: global cognitive function (MMSE) Phy: Handgrip strength Others: Blood pressure, BMI

Table 3 Program of training, intensity, duration and outcomes of exercises (cont')

Authors & Year	Participants	Mean age	program of training	Intensity	Duration	Measurement outcomes
Resistance exercise only						
Coelho-Junior H., et al. 2020 (37)	healthy and cognitively impaired older adults	> 60	Exp: Traditional, high-speed, and circuited resistance training that were performed with dynamic muscle contractions Con: No intervention, stretching, balance, social activities	Moderate to high	2 - 4 sets 1 - 3 days/week 6 - 36 weeks	Cog: global cognitive function, short-term and long-term memory, attention and concentration, set-shifting, spatial awareness, reaction time, and verbal fluency.
Li Z., et al. 2018 (36)	elderly, MCI	55 - 80	Exp: Free weight training, elastic band training and dumbbells barbells training Con: Non-exercise, balance and tone and health education	30 - 100% of 1-RM	30–100 minutes/set 1 - 3 sets/week or 2 - 3 sets of 6 - 15 repetitions 6 - 52 weeks	Cog: global cognitive function, executive function, memory and attention

AD = Alzheimer's Disease, MCI = Mild cognitive impairment

Exp = experimental group, Con = control group, HRmax = maximal heart rate, RM = repetition maximum

Cog = cognitive performance outcomes

ADAS-Cog = Alzheimer's Disease Assessment Scale-Cognitive Subscale, BVRT = Benton Visual Retention Test,

CERAD = Consortium to Establish a Registry for Alzheimer's disease, COAS = California Older Adult Stroop Test,

COWA = Controlled Oral Word Association test, DSST = Digit Symbol Substitution Test, DST = Digit Span Test,

ERFC = Rapid Evaluation of Cognitive Functions test, FAB = Frontal assessment battery, MMSE = Mini-Mental State Examination,

MoCA = Montreal Cognitive Assessment, SDMT = Symbol Digit Modalities Test, The 5-Cog = The Five Cognitive Tests, TMT = Trail Making Test,

WAIS-III = Wechsler Adult Intelligence Scale Third Edition, WMS-R = Wechsler Memory Scale-Revised, YKSST = Yamaguchi Kanji Symbol Substitution Test

Phy = physical performance outcomes

BMI = Body mass Index, SLS = single leg stance test, SPPB = Short Physical Performance Battery, TUG = Timed Up and Go test,

VO2peak = Peak Oxygen Consumption, 6MWT = six-minute walk test

Others = Other outcomes

BDNF = Brain-derived neurotrophic factor, IGF-1 = Insulin-like growth factor-1

BDI = Beck Depression Inventory, GDS = Geriatric Depression Scale, LSA = Life Space Assessment,

MCS = Medical Outcomes 36-Item Short Form (SF-36) mental component summary, NPI = Neuropsychiatric Inventory Questionnaire,

POMS = Profile of mood states, QOL = Quality of Life, QOL-AD = Quality of Life Alzheimer's Disease,

SF-12 = Health questionnaire 12-Item Short Form survey, SF-36 questionnaire = short form 36 health survey questionnaire,

TMIG-IC = Tokyo Metropolitan Institute of Gerontology Index of Competence

Home-based exercise

At present, home-based exercise is one of the most popular options for exercising in older people. Home-based exercise refers to an exercise performed within or around the home with or without a specific exercise program (44). This exercise does not require any exercise equipment or use the equipment that can be found at home. It is considered to be a safe exercise that does not require supervision. People who perform this type of exercise must be able to assess the exercise intensity by themselves for safety reason. There were systematic reviews evaluating the effectiveness of individualized home-based and community-based exercise programs and founded that these interventions significantly improved physical function, mobility and balance in both healthy elderly and older adults with mild cognitive impairment (48, 141). In addition, the effectiveness of home-based exercise was not different from group exercise (142). Therefore, home-based exercise might have an advantage over group exercise in a specified location due to ease of access and home-based exercise can reduce barriers in participation such as the need for travel and other related expenses. However, one of the challenging aspects of home-based exercise was to design the programs that were appropriate for the participants. It should be taken into consideration regarding the factors that support exercise at home, especially safety of the participants.

In summary, exercise is beneficial for cognitive function. Most exercises from recent research studies have used equipment or had to travel to exercise in a specified location causing travel restrictions and increased expenses. Home-based exercise is another intervention of choice to reduce these afore-mentioned problems and prevent the progression of dementia in elderly with mild cognitive impairment. At present, there are studies on home-based or community-based exercise in the elderly and participants with mild cognitive impairment, with the results focused only on functional performance outcome (46, 48). However, there is no evidence that home-based exercise in the form of resistance exercise can improve cognitive function in older people with mild cognitive impairment. In addition, both of aerobic exercise and resistance exercise were found to

be effective in improving cognitive function but there are limited studies comparing aerobic exercise and resistance exercise in elderly with mild cognitive impairment.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter focused on the research methodology for comparing the effect of home-based aerobic exercise and home-based resistance exercise on the cognitive and physical functions in older persons with mild cognitive impairment. These objectives were assessed in three group of participants; aerobic exercise group, resistance exercise group and the control group who did not perform any exercise training.

Study design

A single-blind randomized controlled trial

Study population

Sample size

There were 3 group of participants. The sample size was calculated using the G*Power program, which determined 80% power, the α level of 0.05 and the effect size of 0.3 (143). The sample size were 75 participants (25 participants per group) and when adding 20% drop out, the total sample size were 90 participants (30 participants per group).

Inclusion and exclusion criteria

All participants were recruited using the following criteria:

Inclusion criteria

The inclusion criteria of participants were as followed:

1. Aged 60 years and older.
2. Live in Pathum Thani province.
3. Having mild cognitive impairment as measured by Thai version of the Montreal cognitive Assessment (MoCA), score between 17 – 24 points.
4. Able to stand and walk independently (with or without assistive device).
5. Able to follow verbal instruction.

Exclusion criteria

The exclusion criteria of participants were as followed:

1. Have been diagnosed with dementia.
2. History or diagnosed with neurological diseases, such as stroke, traumatic brain injury.
3. History or diagnosed with cardiovascular diseases, such as myocardial infarction (MI).
4. Having resting blood pressure > 160/100 mmHg.
5. Severe musculoskeletal conditions that disturbing or limiting to follow the exercise program.
6. Having visual and/or hearing impairment that could not be correct with lens and/or hearing aid.
7. Having color blindness and cannot communicate.
8. Participating in other exercise programs.

Termination criteria

In the aerobic and resistance exercise groups, participants were excluded when they were unable to participate in ≥ 75% of the exercise program or ≥ 1,230 minutes of total exercise duration.

Methods and procedures

First of all, the researchers proposed the research protocol for approval from the human ethics committee of Srinakharinwirot University. After the research protocol was approved, all participants who were interested in the study were invited to participate in this study. Before they were recruited in this study, Thai version of Montreal Cognitive Assessment was used for screening mild cognitive impairment, with a score between 17 – 24 points by physical therapists. After that, the participants were informed about the objectives, procedure, benefits, and possible risks of this study before participation. Then, the participants who met the inclusion and exclusion criteria signed a consent form. All participants with mild cognitive impairment in this study were randomly stratified by age and education levels into three groups by rater 1, 1) aerobic

exercise group, 2) resistance exercise group and 3) control group. The home-based exercise was designed with the concern of safety issue such that participants could perform these exercises independently with no risk of fall or physical injury.

All types of training were performed 5 days per week for 3 months by physical therapist (rater 2), each session consisted of a total exercise duration of 35 minutes per day and increase by 5 minutes every 2 weeks. Participants in the aerobic exercise group received an aerobic exercise program at home and were later progressed with increasing number of exercises, number of repetitions and the complexity of the exercises. Participants in the resistance exercise group received a resistance training program using bodyweight, water bottles, etc., and were subsequently progressed by increasing resistance, number of exercises, number of sets or repetitions and the complexity of the exercises as shown in Table 4. Researcher used test results performed prior to exercise (physical performance tests such as 6-minute walk test, 30-second chair stand test, 30-second arm curl test) to determine the fitness level and tolerance of the participant for prescribing the exercise intensity suitable to the fitness level of individual participants. Training programs were explained to the participants in both aerobic and resistance exercise groups and verified on the day of the first program administration before the participants to do the exercises at home to ensure the correction and safety of exercise when performing at home and a separate exercise manual was provided for each group. The Borg Rating of Perceived Exertion scale was also explained so that participants could accurately rate themselves. Participants in the control group were allowed to continue their usual daily life activities.

Table 4 Training program

Weeks	Duration (mins/day)	Exercise groups	
		Aerobic exercise	Resistance exercise
1 - 2	35	*Example of exercise* - Low impact exercise: indoor walk/march in place, step in difference directions and plus arm movement - Light to moderate intensity (≤ 15 point of Borg scale) *Progression* - increase number of exercises, number of repetitions and the complexity of the exercises	*Example of exercise* - Start 6 to 8 exercises with repetitions based on physical performance tests - 30 to 60 seconds rest between sets - Shoulder flexion, abduction - Elbow flexion, extension - Hip extension, abduction - Knee extension - Plantar flexion - Wall push up - Step ups - If the participants complete the exercise before the determined exercise time, they will be asked to perform light exercise such as stretching wrist, finger, ankle and toe movements in sitting until the exercise time is completed. *Progression* - increase resistance, number of exercises, number of sets or repetitions and the complexity of the exercises
3 - 4	40		
5 - 6	45		
7 - 8	50		
9 - 10	55		
11 - 12	60		

The outcome measures were collected before and after 1, 2 and 3 months of exercise and follow-up 3 months after the end of the exercise program by rater 3 who had experience in using the measurement and were blinded to the group of the participant. Cognitive functions were assessed by psychologists and physical functions were assessed by physiotherapists. The Stroop Color and Word Test (SCWT), Digit Span Test (DST), Trail Making Test (TMT) and Stick Design Test (SDT) were used to assess cognitive functions which were performed in the random order with rest between tests and Timed Up and Go Test with manual task (TUG-M), 6-minute walk test (6MWT) and 30-second chair stand test were used to assess physical functions which were performed in the random order with rest between tests. In addition, exercise adherence was recorded, calculated from the total exercise duration of 12 weeks; exercise adherence (%) = (The amount of time participants exercised/The total exercise duration) x 100. The testing procedures were summarized in Figure 1.

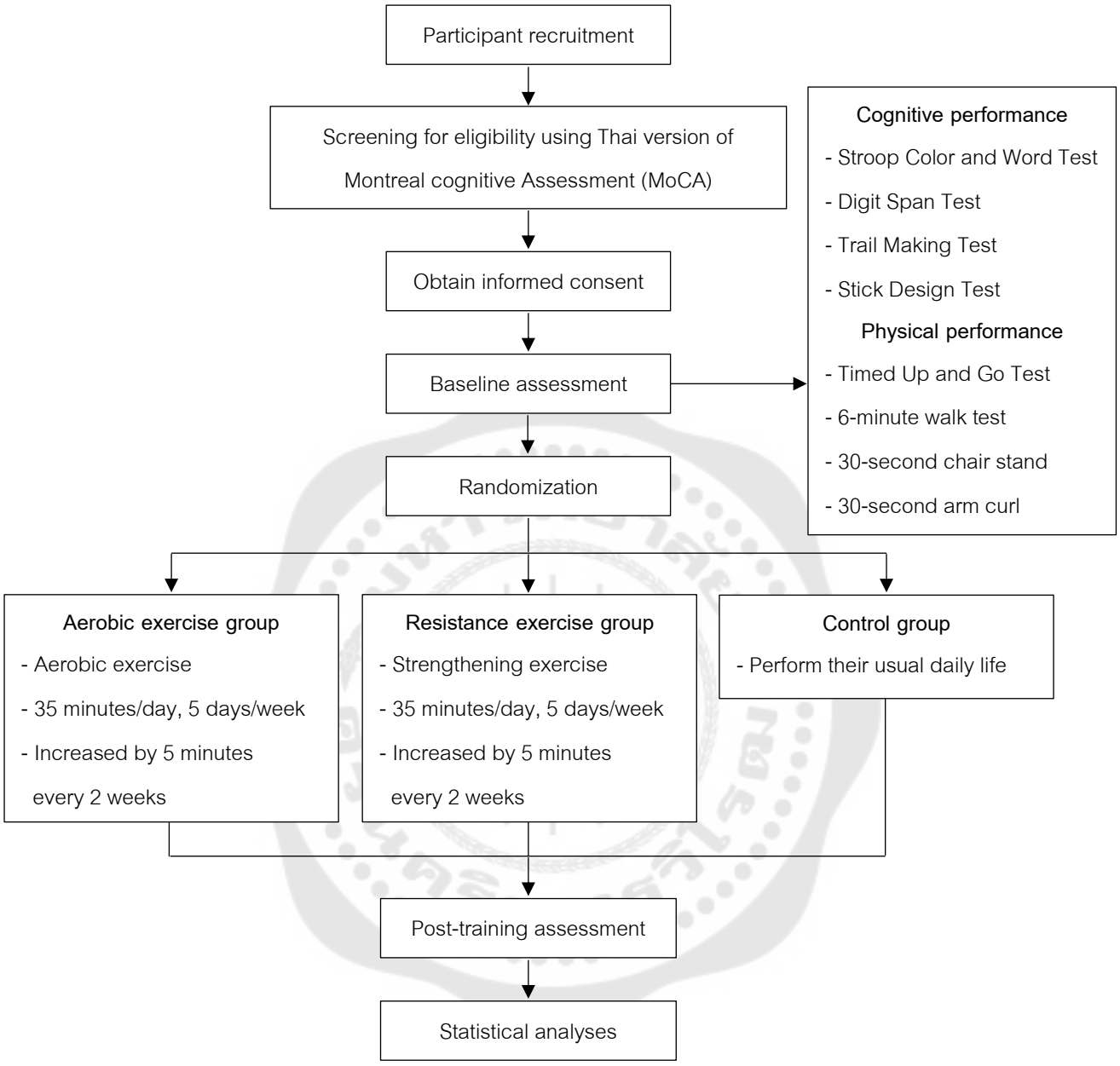

Figure 1 Flow diagram of the study

Intervention

Aerobic exercise group

Participants in the aerobic exercise group performed an aerobic exercise program at home. The participants exercised at light to moderate intensity with a level of exhaustion at ≤ 15 point of Borg scale (144) and they were progressed with increasing number of exercises, number of repetitions and the complexity of the exercises by a

physical therapist who visited every 2 weeks. This intervention was performed 15 minutes per day, 5 days per week for 3 months and increased by 5 minutes every 2 weeks. Each session of exercise program was included a 10-minute warm-up and a 10-minute cool-down. The participants received a logbook for recording their exercise to evaluate their compliance to the exercise program. Further, the participants were monitored by phone every week to encourage them to exercise and to ask for problems that might arise.

Resistance exercise group

Participants in the resistance exercise group performed a resistance training program at home. The participants started the exercise with bodyweight, water bottles or items that could find at home and they were progressed with increasing resistance, number of exercises, number of sets or repetitions and the complexity of the exercises by a physical therapist who visited every 2 weeks. This intervention was performed 15 minutes per day, 5 days per week for 3 months and increased by 5 minutes every 2 weeks. Each session of exercise program was included a 10-minute warm-up and a 10-minute cool-down. The participants received a logbook for recording their exercise to evaluate their compliance to the exercise program. Further, the participants were monitored by phone every week to encourage them to exercise and to ask for problems that might arise, same as aerobic exercise group.

Control group

All participants in the control group were allowed to continue their usual daily life activities, except performing any types of exercise or cognitive training until the study was completed. The participants received a logbook for recording their daily routines and were reviewed by phone every week for monitoring their daily activities and problems that may arise similar to those in the exercise groups. In addition, participants in the control group were asked about their behavior on the day of testing every month and verified with the relatives. The exercise programs were informed for the participants in control group after the intervention was completed.

Outcome measurements

Both cognitive and physical outcomes were measured as follows.

Cognitive performance outcomes

The Montreal Cognitive Assessment (MoCA)

The Montreal Cognitive Assessment (MoCA) was a global cognitive function assessment to screen for cognitive impairment. It assessed cognitive function in areas such as executive function, memory, attention, language, orientation, with a score of 30 points. If the participants have less than 6 years of education, a score would be added to those who had been taken the test by 1 point.

The Stroop Color and Word Test (SCWT)

The Stroop Color and Word Test (SCWT) was a neuropsychological test used for assessing inhibitory control that was part of executive function. Stroop color and word test consisted of 3 subtasks. Subtask 1 (W condition): participants were instructed to read the words (red, blue, yellow, green) that printed with black ink. Subtask 2 (C condition): participants were instructed to name the color of the color display and subtask 3 (CW condition): participants were instructed to name the ink color of the printed words (for example, the word “red” was printed in yellow ink then let the participants named that yellow). Participants were required to do correctly and quickly as possible within 45 seconds. The assessors recorded the number of items that had been completed. If the participants name the wrong word or color during the test, the assessors would instruct the participants to name the word or color in the mistaken list again without counting the points for the wrong naming. The scores obtained from 3 subtasks were used to calculate the interference score (IG) using the formula; $IG = CW - [(W \times C)/(W + C)]$ (145).

The Digit Span Test (DST)

The digit span test (DST) was a neuropsychological test used to assess the short-term memory and working memory. Digit span test generally consisted of two parts: forward and backward digit span test. Forward digit span test required participants to repeat the numbers in the same order that the assessor read, and backward digit span test required participants to repeat the numbers in the reverse

order from the assessor. The length of the number set was from 2-10 numbers, each number set was tested 3 times in a set. If participants answer correctly 2 times, they would pass that number set. This test was finished when the set of numbers was not passed (146).

The Trail Making Test (TMT)

The Trail Making Test (TMT) was a neuropsychological test of attention and mental flexibility. Part A (TMT-A) required participants to draw a line to connect 25 encircled numbers distributed on a page without lifting up pen or pencil. Part B (TMT-B) was similar, except participants had to alternate between numbers and letters sequentially by using the Trail Making Test – Thai Modification (147). Both parts were timed, and the score showed the amount of time required to complete the task. If participants make an error, point out the error and correct it. Time to correct error was included in the completion time for the task (148).

The Stick Design Test (SDT)

The Stick Design Test (SDT) was a neuropsychological test used to assess the visuoconstructional reasoning that was part of perceptual-motor function. The assessor demonstrated the arrangement of matches one by one from 4 predetermined patterns before letting the participant performed the test. After that, the assessor collected all the matches and requireed participants to put the matches in order according to the sample shown by the assessor. Scoring criteria were based on the correctness of the general figure, orientation of the whole figure, and orientation of the match heads within the figure. If the participants do it correctly, they would receive 3 points per figure, with total score 12 points (79).

Physical performance outcomes

The Timed Up and Go Test (TUG)

This study administered the timed up and go with manual task (TUG-M) that required participants to carry a full cup of water while walking (149). The Timed Up and Go Test (TUG) was used to assess mobility, balance and walking ability. It required participants to sit in the chair with their back against the backrest and both feet on the floor. After the assessor commanded "go", the participants stood up

independently from a sitting position, walked along a 3 meters walkway as fast as the participants felt safe and comfortable, turned around the cone, walked back to the chair and sat down. Timing was recorded at the assessor commanded "go" until the participants sat down with back against the backrest of the chair (150). The participants might use their hands to push up when got up from the chair and might use gait assistive device that they normally used while performing the test but might not be assisted by another person. The assessor recorded gait assistive device.

The 6-Minute Walk Test (6MWT)

The six-minute walk test (6MWT) was used to assess aerobic capacity or endurance. Participants were instructed to walk with preferred walking speed as far as possible in 6 minutes. They were not allowed to talk during walking and were notified of each minute left. They could use an assistive device that they normally used while performing the test and might take a rest as needed if they feel tired or discomfort while time was still ongoing. The assessor recorded the number of rests taken, the total rest time and an assistive device. Walking distance was measured in meters over 6 minutes (151). This test was performed for 1 time and data was used for study.

The 30-second Chair Stand Test

The 30-second chair stand test was used to assess lower extremity strength. This test required participants to sit in the middle of the chair with back straight, both feet on the floor and arms folded across the chest. Participants were instructed to fully stand alternately with fully sit as many as possible within 30 seconds. This test was performed for 1 time and could be practiced a repetition or 2 before the test. The score was the total number of the completion of stands within 30 seconds. If the participants use their hands to push up when stood up from the chair, they would be scored 0 point (152).

The 30-second Arm Curl Test

The 30-second arm curl test was used to assess upper extremity strength. This test was performed before starting an exercise program to determine the appropriate exercise intensity for each participant's fitness. The 30-second arm curl test

required participants to sit in the chair, holding the weight on the dominant arm side with palm facing to the body (women used 5 pounds and men used 8 pounds). Participants were instructed to bend their arm up and lower their arm down through range of motion as many as possible within 30 seconds. During the test, the participant's upper arm was be braced against the body so that only the lower arm could move (the assessor might help to hold the participant's upper arm). This test was performed for 1 time. The score was the total number of the completion of arm curl within 30 seconds (152).

Statistical analyses

Data were analyzed using Statistics program IBM- SPSS version 22 for Windows. Descriptive statistics were used to describe general characteristics of the participants. These analyses included all participants according to the intent-to-treat principle. Missing data at follow-up were replaced with post-training data. The distribution of all data calculated by the Kolmogorov-Smirnov test showed it was not normal distribution so the Kruskal-Wallis test were used for comparison between 3 groups at pre-training, post-training and follow-up period. The Wilcoxon Signed Ranks test was used to compare the effect of exercise on cognitive and physical variables within groups and the Mann-Whitney U test was used to compare the effects of exercise on cognitive and physical variables between groups. The statistical significance in this study was set at 0.05. Effect sizes were calculated to estimate the magnitude of differences in outcome variables between groups. The criteria for interpreting 0.2, 0.5 and 0.8 were small, medium and large effects, respectively (153). Data are reported as the mean ± SD across all outcome variables and 95% CI in comparisons of outcome variables between groups.

CHAPTER 4
RESULTS

Subject characteristics and pre-training assessments before starting the exercise program are presented in Table 5. A total of 90 subjects with an average age of 69.00 ± 5.03 years completed the 3-month exercise program. All 3 groups had similar characteristics, with the majority being female, having less than 6 years of education, doing housework, and low physical activity levels (<600 MET minute per week). The exception is for marital status where most of the resistance groups are married, while the majority of the other two groups were single. In addition, all cognitive variables, including MoCA, TMT-A, TMT-B, SCWT, DST-F, DST-B and SDT, as well as physical variables (TUG-M, 6MWT and 30-second chair stand test) were not different among three groups at pre-training.

Table 5 Subject characteristics and pre-training neuropsychological assessments and physical performance

	All participants (N = 90)		Aerobic group (N = 30)		Resistance group (N = 30)		Control group (N = 30)	
	N	%	N	%	N	%	N	%
Female	71	78.89	24	80.00	23	76.67	24	80.00
Marital status (Marriage)	46	51.11	14	46.67	19	63.33	13	43.33
Education level								
(Academic years ≤ 6)	48	53.33	16	53.33	16	53.33	16	53.33
Employment status								
Employment	16	17.78	6	20.00	5	16.67	5	16.67
Unemployment	15	16.67	5	16.67	3	10.00	7	23.33
Housework	59	65.56	19	63.33	22	73.33	18	60.00
Level of physical activity (MET minutes per week)								
Low (< 600)	51	56.67	18	60.00	17	56.67	16	53.33
Moderate (600 – 1,500)	29	32.22	7	23.33	9	30.00	13	43.33
High (≥ 1,500)	10	11.11	5	16.67	4	13.33	1	3.33
	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)	
Age (years)	69.00 (5.03)		68.60 (4.86)		68.70 (4.72)		69.70 (5.55)	
MoCA (score)	20.06 (1.94)		20.17 (2.09)		19.60 (1.83)		20.40 (1.87)	
TMT-A (second)	71.32 (38.37)		60.01 (17.41)		77.50 (40.33)		76.45 (48.88)	
TMT-B (second)	199.88 (161.00)		174.95 (174.26)		185.64 (157.66)		239.04 (147.96)	
SCWT (score)	-13.62 (6.98)		-13.66 (6.43)		-15.61 (6.10)		-11.59 (7.92)	
DST-F (score)	6.23 (1.26)		6.27 (1.34)		5.93 (1.11)		6.50 (1.31)	
DST-B (score)	2.86 (0.53)		2.90 (0.61)		2.77 (0.50)		2.90 (0.48)	
SDT (score)	9.26 (1.50)		9.27 (1.53)		9.30 (1.47)		9.20 (1.56)	
TUG-M (second)	15.28 (3.88)		14.56 (3.02)		16.21 (4.32)		15.08 (4.13)	
6MWT (meter)	366.01 (53.53)		362.03 (42.40)		364.20 (51.24)		371.80 (65.69)	
30-second chair stand test (score)	12.28 (2.33)		12.90 (2.51)		11.97 (2.28)		11.97 (2.13)	

Abbreviations: DST-F = Forward Digit Span Test; DST-B = Backward Digit Span Test; MET = Metabolic Equivalent of Task; MoCA = Montreal Cognitive Assessment; SCWT = Stroop Color and Word Test; SDT = Stick Design Test; TMT = Trail Making Test; TUG-M = Timed Up and Go Test with manual task, 6MWT = six-minute walk test

Within group effect

Participants in the aerobic and resistance exercise groups showed high adherence to the exercise program with 94.83 ± 3.48% and 96.67 ± 3.16%, respectively with exercising on average 3 - 5 days per week. All participants had an exhaustion level range from 8 to 13, with participants in the aerobic group reported the exhaustion level with the median of 11 from Borg scale which was the same median value as those in the resistance group. After exercise, no participants reported any serious adverse effects, only muscle fatigue and those symptoms improved after resting. The effects of exercise on cognitive and physical performance within each group; aerobic, resistance and control group, during 3-month post-training and follow-up, compared to pre-training are shown in Table 6. Both aerobic and resistance groups demonstrated significant improvement on global cognitive function as measured by MoCA, during post-training and able to sustain until follow-up. With the exception of stick design test (SDT), improvement in all specific cognitive functions, including TMT-A, TMT-B, SCWT, DST-F, DST-B and TUG-M, were also evident in both aerobic and resistance groups during post-training and follow-up. However, 6MWT of the aerobic group showed significant improvement at post-training and follow-up, while the 30-second chair stand test found improvement only in the resistance group. The effect sizes of all outcome variables within groups for both the aerobic and resistance groups ranged between 0.35 and 0.62. In contrast, control group did not show the improvement in cognitive and physical performance at post-training and follow-up.

Table 6 Comparison of changes in cognitive function domains and physical performance outcomes within groups at post-training and follow-up.

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
MoCA (score)									
Pre-training	20.17 (2.09)			19.60 (1.83)			20.40 (1.87)		
Post-training	25.40 (2.54)	25.93	0.62* [4.61, 5.86]	24.53 (2.90)	25.15	0.61* [4.04, 5.82]	21.17 (2.77)	3.77	0.18 [-1.89, 0.36]
Follow-up	24.63 (2.67)	22.11	0.62* $ [3.63, 5.30]	23.47 (3.21)	19.74	0.59* $ [2.89, 4.84]	21.70 (3.56)	6.37	0.22 [-2.68, 0.08]
TMT-A (second)									
Pre-training	60.01 (17.41)			77.50 (40.33)			76.45 (48.88)		
Post-training	39.53 (10.70)	-34.13	-0.59* [-25.51, -15.45]	45.83 (22.92)	-40.86	-0.62* [-39.76, -23.58]	65.68 (36.37)	-14.09	-0.25 [-1.39, 21.93]
Follow-up	47.75 (16.42)	-20.43	-0.46* $ [-17.77, -6.76]	50.91 (27.92)	-34.31	-0.54* [-38.66, -14.52]	64.96 (31.78)	-15.03	-0.25 [-1.33, 21.63]

Table 6 Comparison of changes in cognitive function domains and physical performance outcomes within groups at post-training and follow-up. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
TMT-B (second)									
Pre-training	174.95 (174.26)			185.64 (157.66)			239.04 (147.96)		
Post-training	78.26 (34.08)	-55.27	-0.62* [-156.33, -37.04]	88.26 (52.83)	-52.46	-0.62* [-140.56, -54.19]	154.36 (92.64)	-35.43	-0.52* [-120.51, -48.87]
Follow-up	88.55 (44.77)	-49.39	-0.62* $ [-145.79, -26.99]	103.22 (68.97)	-44.40	-0.60* $ [-122.50, -42.33]	160.48 (115.08)	-32.86	-0.60* [-108.58, -48.55]
SCWT (score)									
Pre-training	-13.66 (6.43)			-15.61 (6.10)			-11.59 (7.92)		
Post-training	-0.38 (6.78)	97.22	0.62* [11.02, 15.54]	-4.64 (6.79)	70.28	0.62* [9.11, 12.82]	-12.25 (6.46)	-5.69	-0.06 [-2.83, 4.15]
Follow-up	-5.14 (8.85)	62.37	0.55* $ [5.60, 11.42]	-8.62 (7.75)	44.78	0.59* $ [5.11, 8.87]	-11.48 (6.13)	0.95	0.07 [-3.64, 3.42]

Table 6 Comparison of changes in cognitive function domains and physical performance outcomes within groups at post-training and follow-up. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
DST-F (score)									
Pre-training	6.27 (1.34)			5.93 (1.11)			6.50 (1.31)		
Post-training	7.90 (1.27)	25.99	0.61* [1.26, 2.01]	7.50 (1.20)	26.48	0.59* [1.19, 1.94]	6.53 (1.11)	0.46	0.05 [-0.41, 0.34]
Follow-up	7.07 (1.20)	12.76	0.48* $ [0.48, 1.12]	6.70 (1.32)	12.98	0.41* $ [0.37, 1.17]	6.60 (0.93)	1.54	0.06 [-0.55, 0.35]
DSR-B (score)									
Pre-training	2.90 (0.61)			2.77 (0.50)			2.90 (0.48)		
Post-training	3.67 (1.09)	26.55	0.47* [0.45, 1.09]	3.40 (0.77)	22.74	0.46* [0.37, 0.90]	3.00 (0.59)	3.45	0.12 [-0.33, 0.13]
Follow-up	3.47 (1.14)	19.66	0.40* [0.25, 0.89]	3.17 (0.59)	14.44	0.38* [0.17, 0.63]	3.07 (0.52)	5.86	0.22 [-0.36, 0.31]

Table 6 Comparison of changes in cognitive function domains and physical performance outcomes within groups at post-training and follow-up. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
SDT (score)									
Pre-training	9.27 (1.53)			9.30 (1.47)			9.20 (1.56)		
Post-training	9.67 (1.49)	4.31	0.22 [-0.84, 0.05]	9.77 (1.63)	5.05	0.20 [-1.04, 0.10]	9.47 (1.41)	2.93	0.13 [-0.92, 0.38]
Follow-up	9.47 (1.17)	2.16	0.08 [-0.79, 0.39]	9.50 (1.31)	2.15	0.07 [-0.76, 0.36]	9.33 (1.40)	1.41	0.07 [-0.69, 0.43]
TUG-M (second)									
Pre-training	14.56 (3.02)			16.21 (4.32)			15.08 (4.13)		
Post-training	11.24 (1.79)	-22.80	-0.62* [-4.08, -2.55]	11.94 (3.07)	-26.34	-0.62* [-5.11, -3.42]	15.38 (5.55)	1.99	0.01 [-1.85, 1.26]
Follow-up	13.03 (3.73)	-10.51	-0.37* $ [-2.96, -0.09]	13.66 (3.73)	-15.73	-0.44* $ [-3.79, -1.29]	15.26 (5.79)	1.19	0.04 [-1.86, 1.52]

Table 6 Comparison of changes in cognitive function domains and physical performance outcomes within groups at post-training and follow-up. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
6MWT (meter)									
Pre-training	362.03 (42.40)			364.20 (51.24)			371.80 (65.69)		
Post-training	425.40 (43.86)	17.50	0.62* [52.30, 74.43]	379.67 (62.27)	4.25	0.26 [-33.77, 2.84]	382.33 (61.26)	2.83	0.19 [-29.20, 8.14]
Follow-up	393.50 (58.48)	8.69	0.40* $ [13.49, 49.44]	369.43 (64.85)	1.44	0.05 [-25.86, 15.39]	364.77 (68.33)	-1.89	-0.14 [-11.49, 25.56]
30-seond chair stand test (score)									
Pre-training	12.90 (2.51)			11.97 (2.28)			11.97 (2.13)		
Post-training	13.37 (2.59)	3.64	0.16 [-1.17, 0.24]	13.53 (2.93)	13.03	0.39* [0.61, 2.53]	12.43 (2.43)	3.84	0.13 [-1.38, 0.45]
Follow-up	13.03 (2.36)	1.01	0.07 [-0.66, 0.39]	13.17 (3.13)	10.03	0.35* [0.35, 2.05]	12.40 (2.06)	3.59	0.14 [-1.23, 0.36]

Abbreviations: DST-F = Forward Digit Span Test; DST-B = Backward Digit Span Test; MoCA = Montreal Cognitive Assessment; SCWT = Stroop Color and Word Test; SDT = Stick Design Test; TMT = Trail Making Test; TUG-M = Timed Up and Go Test with manual task, 6MWT = six-minute walk test (Negative values of TMT-A, TMT-B and TUG-M mean improvement)

* Indicates statistical significance compared with the pre-training at $p<0.05$, $ Indicates statistical significance compared with the post-training at $p<0.05$.

Between group effect

The effects of exercise on cognitive and physical performance when compared between 3 groups: aerobic group, resistance group, and control group at pre-training, 3 months post-training and follow-up are shown in Figure 2 and Figure 3. Details on 95%CI and effect size of each pair comparison during post-training and follow-up are listed in Table 7. As compared to the control group, aerobic group differed significantly in MoCA, TMT-A, TMT-B and SCWT at post-training and follow-up. However, DST-F, DST-B, TUG-M and 6MWT of the aerobic group showed higher improvement than the control group only at post-training. For the resistance group, this group significantly improved in MoCA and TMT-B than the control group at post-training and follow-up, while TMT-A, SCWT, DST-F, DST-B, TUG-M and 30-second chair stand test of this group differed from the control group only at the post-training. Effect sizes of all outcome variables between the aerobic and the control group and the resistance and the control group were in the range of 0.30 – 0.68 and 0.26 – 0.52, respectively. However, there were no differences in cognitive and physical performances after training between aerobic and resistance group, except the inhibitory control and aerobic endurance as measured by SCWT and 6MWT, respectively that significantly better in the aerobic group than the resistance group at post-training and the effect sizes of SCWT and 6MWT were 0.29 and 0.37, respectively.

Table 7 Comparison of changes in cognitive function domains and physical performance outcomes between groups at post-training and follow-up.

	Aerobic & Control		Resistance & Control		Aerobic & Resistance	
Outcome measures	Effect size	95% CI	Effect size	95% CI	Effect size	95% CI
MoCA						
Post-training	0.64*	[2.86, 5.61]	0.52*	[1.90, 4.83]	0.15	[-0.54, 2.28]
Follow-up	0.42*	[1.30, 4.56]	0.26*	[0.13, 3.52]	0.18	[-0.36, 2.70]
TMT-A						
Post-training	-0.54*	[-40.22, -12.08]	-0.39*	[-35.62, -4.08]	-0.09	[-15.62, 3.03]
Follow-up	-0.30*	[-30.38, -4.05]	-0.30	[-29.52, 1.41]	-0.01	[-15.06, 8.74]
TMT-B						
Post-training	-0.56*	[-112.62, -39.57]	-0.46*	[-105.29, -26.91]	-0.06	[-33.06, 13.06]
Follow-up	-0.35*	[-117.58, -26.27]	-0.27*	[-106.52, -7.99]	-0.08	[-44.83, 15.48]
SCWT						
Post-training	0.68*	[8.45, 15.29]	0.51*	[4.19, 11.03]	0.29*	[0.76, 7.77]
Follow-up	0.41*	[2.39, 10.28]	0.24	[-0.75, 6.48]	0.21	[-0.83, 7.78]
DST-F						
Post-training	0.50*	[0.75, 1.98]	0.38*	[0.37, 1.56]	0.17	[-0.24, 1.04]
Follow-up	0.22	[-0.09, 1.02]	0.04	[-0.49, 0.69]	0.14	[-0.29, 1.02]
DST-B						
Post-training	0.38*	[0.21, 1.12]	0.29*	[0.05, 0.75]	0.10	[-0.22, 0.76]
Follow-up	0.19	[-0.06, 0.86]	0.11	[-0.19, 0.39]	0.09	[-0.17, 0.77]
SDT						
Post-training	0.12	[-0.55, 0.95]	0.10	[-0.49, 1.09]	-0.03	[-0.91, 0.71]
Follow-up	0.03	[-0.53, 0.80]	0.05	[-0.53, 0.87]	-0.03	[-0.67, 0.61]
TUG-M						
Post-training	-0.54*	[-6.30, -1.98]	-0.37*	[-5.77, -1.11]	-0.11	[-2.00, 0.61]
Follow-up	-0.23	[-4.75, 0.30]	-0.12	[-4.12, 0.93]	-0.12	[-2.56, 1.30]
6MWT						
Post-training	0.37*	[15.47, 70.66]	0.01	[-34.59, 29.26]	0.37*	[17.83, 73.64]
Follow-up	0.18	[-4.15, 61.62]	0.03	[-29.76, 39.10]	0.18	[-7.85, 55.99]

Table 7 Comparison of changes in cognitive function domains and physical performance outcomes between groups at post-training and follow-up. (cont')

	Aerobic & Control		Resistance & Control		Aerobic & Resistance	
Outcome measures	Effect size	95% CI	Effect size	95% CI	Effect size	95% CI
30-second chair stand test						
Post-training	0.19	[-0.37, 2.23]	0.27*	[0.29, 2.49]	0.11	[-1.60, 1.26]
Follow-up	0.09	[-0.51, 1.78]	0.10	[-0.61, 2.14]	0.01	[-1.57, 1.30]

Abbreviations: DST-F = Forward Digit Span Test; DST-B = Backward Digit Span Test; MoCA = Montreal Cognitive Assessment; SCWT = Stroop Color and Word Test; SDT = Stick Design Test; TMT = Trail Making Test; TUG-M = Timed Up and Go Test with manual task, 6MWT = six-minute walk test

* Indicates statistical significance at p<0.05

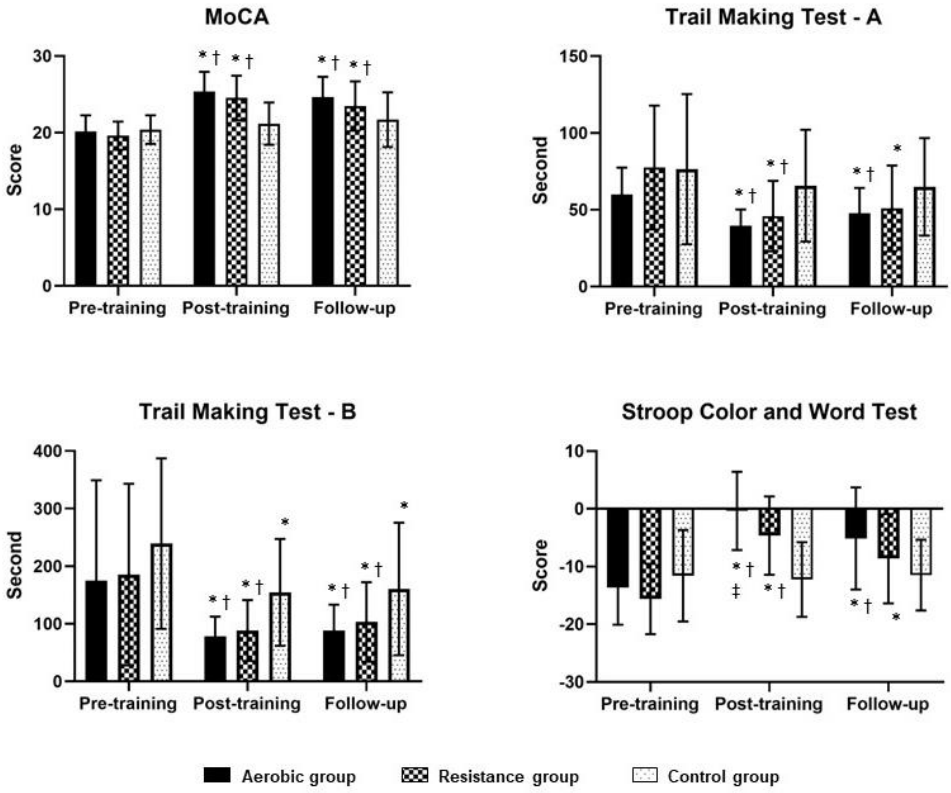

Figure 2 Comparison of changes in cognitive function domains between the 3 groups at post-training and follow-up

* Significance compared with the pre-training at p<0.05; † Significance compared with the control group during the same time at p<0.05; ‡ Significance compared with the resistance group during the same time at p<0.05.

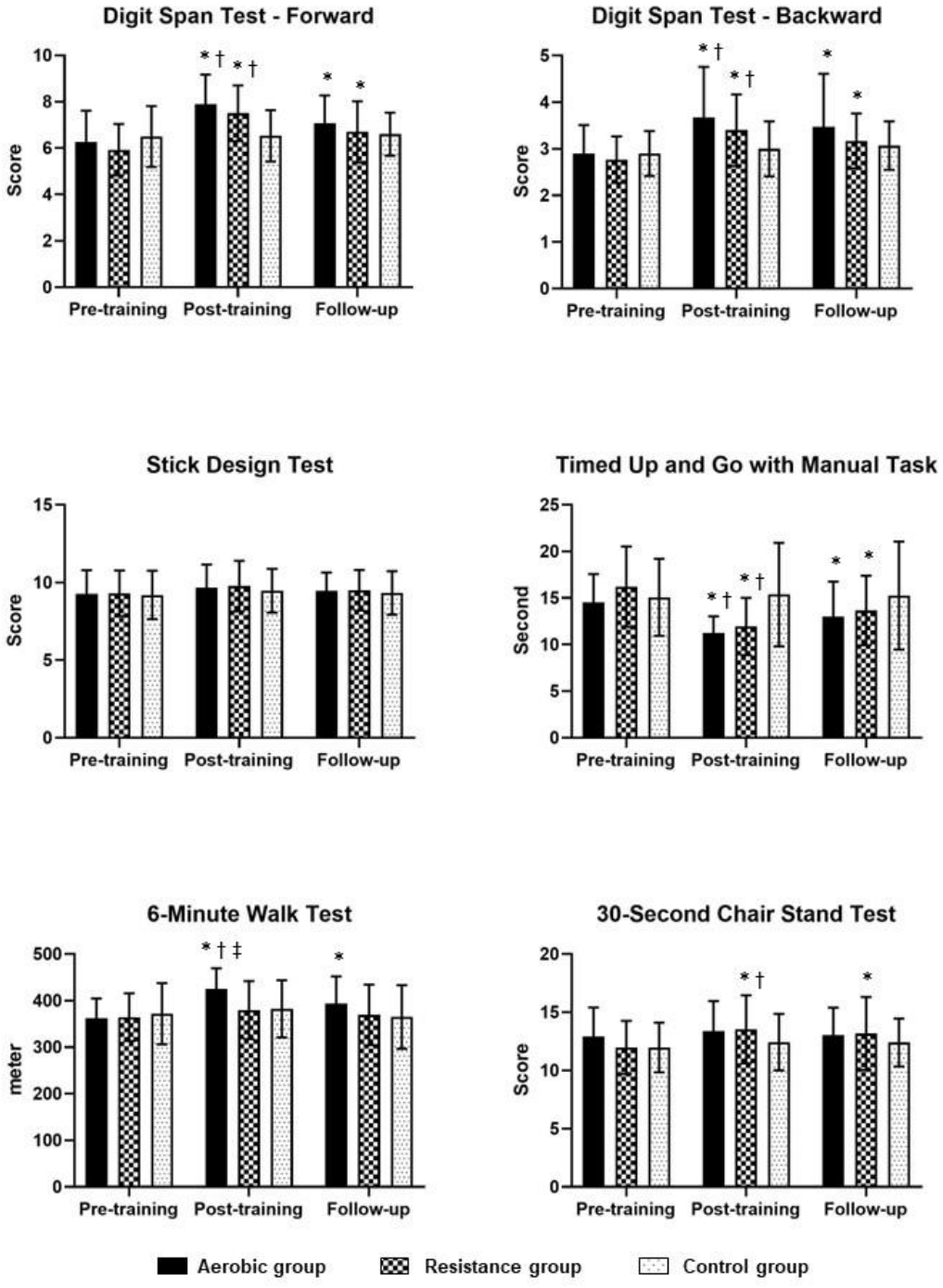

Figure 3 Comparison of changes in cognitive function domains and physical performances between the 3 groups at post-training and follow-up

* Significance compared with the pre-training at $p<0.05$; † Significance compared with the control group during the same time at $p<0.05$; ‡ Significance compared with the resistance group during the same time at $p<0.05$.

Cognitive and physical performance changes during each month of training

Changes in cognitive and physical performance after receiving the exercise program at 1, 2 and 3 months in each group; aerobic group, resistance group, and control group are shown in Table 8. Both aerobic and resistance groups showed significant improvements in MoCA, SCWT and TUG-M at 2 months post-training, while no changes were found in other variables during 1-month and 2-month after training. There were also significant improvements in the 6MWT and 30-second chair stand test in the aerobic and resistance groups, respectively, after 2 months post-training. The effect sizes of all outcome variables within groups ranged of 0.47 - 0.62 and 0.34 - 0.62 for the aerobic and resistance groups, respectively. In contrast, the control group did not demonstrate any improvement in cognitive and physical performance over 1-2 months. This suggested that the earliest significant improvement of MoCA, SCWT, TUG-M, 6MWT and 30-second chair stand test were evident after 2 months after training. However, both aerobic and resistance groups significantly improved in all variables at 3 months post-training except the SDT.

Table 8 Comparison of changes in cognitive function domains and physical performance outcomes in each group at 1, 2 and 3 months.

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
MoCA (score)									
Pre-training	20.17 (2.09)			19.60 (1.83)			20.40 (1.87)		
1-month	21.10 (1.90)	4.61	0.21 [-2.12, 0.25]	20.40 (1.94)	4.08	0.18 [-1.77, 0.17]	20.57 (2.51)	0.83	0.11 [-1.04, 0.71]
2-month	22.60 (2.36)	12.05	0.57* [1.83, 3.04]	21.60 (2.59)	10.20	0.56* [1.44, 2.56]	20.90 (2.66)	2.45	0.11 [-1.71, 0.71]
3-month	25.40 (2.54)	25.93	0.62* [4.61, 5.86]	24.53 (2.90)	25.15	0.61* [4.04, 5.82]	21.17 (2.77)	3.77	0.18 [-1.89, 0.36]
TMT-A (second)									
Pre-training	60.01 (17.41)			77.50 (40.33)			76.45 (48.88)		
1-month	55.26 (15.10)	-7.92	-0.12 [-1.83, 11.34]	70.82 (37.28)	-8.62	-0.05 [-10.27, 23.63]	71.83 (47.93)	-6.04	-0.07 [-5.05, 14.28]
2-month	51.28 (14.41)	-14.55	-0.20 [-0.55, 18.02]	64.99 (34.71)	-16.14	-0.16 [-5.35, 30.38]	73.43 (41.52)	-3.95	-0.06 [-9.02, 15.05]
3-month	39.53 (10.70)	-34.13	-0.59* [-25.51, -15.45]	45.83 (22.92)	-40.86	-0.62* [-39.76, -23.58]	65.68 (36.37)	-14.09	-0.25 [-1.39, 21.93]

Table 8 Comparison of changes in cognitive function domains and physical performance outcomes in each group at 1, 2 and 3 months. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
TMT-B (second)									
Pre-training	174.95 (174.26)			185.64 (157.66)			239.04 (147.96)		
1-month	155.11 (129.45)	-11.34	-0.13 [-31.01, 70.68]	160.10 (118.69)	-13.76	-0.08 [-32.39, 83.46]	220.73 (145.15)	-7.66	-0.16 [-16.08, 52.70]
2-month	123.63 (108.84)	-29.33	-0.30 [-15.54, 118.17]	129.69 (82.19)	-30.13	-0.27 [-2.94, 108.95]	182.46 (122.56)	-23.6	-0.42 [-2.54, 87.73]
3-month	78.26 (34.08)	-55.27	-0.62* [-156.33, -37.04]	88.26 (52.83)	-52.46	-0.62* [-140.56, -54.19]	154.36 (92.64)	-35.43	-0.52* [-120.51, -48.87]
SCWT (score)									
Pre-training	-13.66 (6.43)			-15.61 (6.10)			-11.59 (7.92)		
1-month	-11.08 (5.99)	18.89	0.22 [-6.13, 0.98]	-13.70 (5.79)	12.24	0.15 [-4.57, 0.75]	-12.08 (7.03)	-4.23	-0.09 [-2.58, 3.56]
2-month	-8.28 (6.20)	39.39	0.59* [3.76, 6.99]	-11.69 (5.91)	25.11	0.57* [2.61, 5.22]	-11.99 (7.29)	-3.45	-0.04 [-3.32, 4.12]
3-month	-0.38 (6.78)	97.22	0.62* [11.02, 15.54]	-4.64 (6.79)	70.28	0.62* [9.11, 12.82]	-12.25 (6.46)	-5.69	-0.06 [-2.83, 4.15]

Table 8 Comparison of changes in cognitive function domains and physical performance outcomes in each group at 1, 2 and 3 months. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
DST-F (score)									
Pre-training	6.27 (1.34)			5.93 (1.11)			6.50 (1.31)		
1-month	6.57 (1.04)	4.78	0.11 [-0.86, 0.26]	6.27 (1.08)	5.73	0.14 [-0.92, 0.25]	6.50 (1.20)	0.00	0.00 [-0.43, 0.43]
2-month	6.73 (1.26)	7.34	0.20 [-1.05, 0.12]	6.40 (1.04)	7.93	0.24 [-1.08, 0.14]	6.53 (1.20)	0.46	0.02 [-0.52, 0.45]
3-month	7.90 (1.27)	25.99	0.61* [1.26, 2.01]	7.50 (1.20)	26.48	0.59* [1.19, 1.94]	6.53 (1.11)	0.46	0.05 [-0.41, 0.34]
DSR-B (score)									
Pre-training	2.90 (0.61)			2.77 (0.50)			2.90 (0.48)		
1-month	3.07 (0.74)	5.86	0.13 [-0.48, 0.14]	2.90 (0.48)	4.69	0.21 [-0.29, 0.08]	3.03 (0.56)	4.48	0.16 [-0.35, 0.80]
2-month	3.20 (0.85)	10.34	0.24 [-0.61, 0.12]	3.00 (0.45)	8.30	0.34 [-0.39, 0.07]	3.03 (0.32)	4.48	0.21 [-0.29, 0.29]
3-month	3.67 (1.09)	26.55	0.47* [0.45, 1.09]	3.40 (0.77)	22.74	0.46* [0.37, 0.90]	3.00 (0.59)	3.45	0.12 [-0.33, 0.13]

Table 8 Comparison of changes in cognitive function domains and physical performance outcomes in each group at 1, 2 and 3 months. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
SDT (score)									
Pre-training	9.27 (1.53)			9.30 (1.47)			9.20 (1.56)		
1-month	9.37 (1.65)	1.08	0.08 [-0.55, 0.35]	9.47 (1.43)	1.83	0.09 [-0.77, 0.44]	9.37 (1.56)	1.85	0.09 [-0.70, 0.37]
2-month	9.53 (1.72)	2.80	0.13 [-0.75, 0.21]	9.60 (1.63)	3.23	0.14 [-0.86, 0.26]	9.40 (1.77)	2.17	0.08 [-0.70, 0.30]
3-month	9.67 (1.49)	4.31	0.22 [-0.84, 0.05]	9.77 (1.63)	5.05	0.20 [-1.04, 0.10]	9.47 (1.41)	2.93	0.13 [-0.92, 0.38]
TUG-M (second)									
Pre-training	14.56 (3.02)			16.21 (4.32)			15.08 (4.13)		
1-month	13.81 (2.50)	-5.15	-0.10 [-0.57, 2.07]	15.09 (3.96)	-6.91	-0.15 [-0.69, 2.94]	14.68 (3.37)	-2.65	-0.08 [-0.47, 1.27]
2-month	13.19 (2.11)	-9.41	-0.58* [-2.00, -0.74]	14.33 (3.76)	-11.59	-0.59* [-2.60, -1.16]	16.25 (3.97)	7.76	0.31 [-2.32, 0.10]
3-month	11.24 (1.79)	-22.80	-0.62* [-4.08, -2.55]	11.94 (3.07)	-26.34	-0.62* [-5.11, -3.42]	15.38 (5.55)	1.99	0.01 [-1.85, 1.26]

Table 8 Comparison of changes in cognitive function domains and physical performance outcomes in each group at 1, 2 and 3 months. (cont')

Outcome measures	Aerobic group (N = 30)			Resistance group (N = 30)			Control group (N = 30)		
	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI	Mean (SD)	% change	Effect size 95% CI
6MWT (meter)									
Pre-training	362.03 (42.40)			364.20 (51.24)			371.80 (65.69)		
1-month	376.37 (44.68)	3.96	0.27 [-25.75, 2.92]	364.60 (59.47)	0.11	0.01 [-18.95, 18.18]	367.90 (55.93)	-1.05	-0.09 [-14.45, 22.25]
2-month	388.10 (45.84)	7.20	0.59* [16.85, 35.29]	378.57 (61.28)	3.95	0.17 [-32.61, 3.88]	364.77 (58.07)	-1.62	-0.11 [-13.09, 25.16]
3-month	425.40 (43.86)	17.50	0.62* [52.30, 74.43]	379.67 (62.27)	4.25	0.26 [-33.77, 2.84]	382.33 (61.26)	2.83	0.19 [-29.20, 8.14]
30-seond chair stand test (score)									
Pre-training	12.90 (2.51)			11.97 (2.28)			11.97 (2.13)		
1-month	13.13 (2.47)	1.78	0.07 [-0.87, 0.41]	12.07 (2.32)	0.84	0.04 [-0.73, 0.53]	12.13 (2.35)	1.34	0.03 [-0.91, 0.57]
2-month	13.50 (2.30)	4.65	0.19 [-1.39, 0.19]	13.10 (2.50)	944	0.34* [0.35, 1.92]	12.23 (2.01)	2.17	0.07 [-1.04, 0.51]
3-month	13.37 (2.59)	3.64	0.16 [-1.17, 0.24]	13.53 (2.93)	13.03	0.39* [0.61, 2.53]	12.43 (2.43)	3.84	0.13 [-1.38, 0.45]

Abbreviations: DST-F = Forward Digit Span Test; DST-B = Backward Digit Span Test; MoCA = Montreal Cognitive Assessment; SCWT = Stroop Color and Word Test; SDT = Stick Design Test; TMT = Trail Making Test; TUG-M = Timed Up and Go Test with manual task, 6MWT = six-minute walk test

* Indicates statistical significance compared with the pre-training at $p<0.05$, Negative values of TMT-A, TMT-B and TUG-M mean improvement.

CHAPTER 5
DISCUSSION

This study examined the effects of 2 types of low intensity home-based exercise; aerobic and resistance exercise, on cognitive function in people with mild cognitive impairment. The uniqueness of this study is that it was a single-blind randomized controlled trial to compare the effect of aerobic and resistance exercise programs in the same study. Results revealed that at 3-month post-training, both aerobic and resistance exercises could improve physical performance as well as all cognitive domains, with the exception of perceptual-motor function domain (visuoconstructional reasoning). This study also showed that such improvements were able to maintain up to 3-month after the training (follow-up phase).

The exercise program in this study was classified as low intensity, as evidenced by the exhaustion level of 11 points on the Borg scale (154). Based on FITT-VP principle that include: frequency, intensity, time, type, volume or total amount of exercise, and progression, exercise programs in this study had sufficient exercise volume, adjusted to high frequency and high total duration to induce changes in cognitive function. Additionally, the exercise with low intensity and the initial exercise duration of 15 minutes might be the reason for high exercise adherence of the participants and no drop out from exercise programs. This is because most of the participants in this study had low physical activity levels, when participants started exercising at low intensity and short periods of time, participants did not feel overload and were able to complete the entire program each session. In this study, significantly large changes in scores of SCWT, TMT-A and TMT-B were observed in the aerobic and resistance exercise groups after 3-month post-training. A study investigated the minimal clinically important differences (MCID) of SCWT, TMT-A and TMT-B had values of 9.3, 13.0 and 20.1, respectively (155). When compared with this study, it was found that there are clinical changes in executive function (mental flexibility and inhibitory control) and attention (processing speed).

The improvements in cognitive function from aerobic and resistance exercise were in the same lines as the previous research. Regarding low intensity aerobic exercise, a significant increase in cognitive function was supported by Byun K, et al. (156) who concluded that mild aerobic exercise intervention improved executive function, namely inhibitory control in the older adults. Similarly, previous systematic reviews (40-42) suggested that moderate intensity aerobic exercise intervention increased global cognitive function, working memory and attention in older people with mild cognitive impairment. This present study, however, observed improvements in mental flexibility and memory domains that was contrary to previous systematic reviews (26, 41). One possible explanation could by the use of different outcome measures. Previous study had measured delayed recall using an auditory verbal learning test (26) but this study measured short-term memory using DST-F. In the case of mental flexibility, discrepancy may lie in the data for analysis, previous study analyzed data from both aerobic and resistance exercises (41) but this study separated data into either aerobic or resistance exercise.

In addition, the improved cognitive function in this study might be due to the complexity of the exercises. Previous studies had showed that aerobic exercise usually took the form of walking or cycling (26, 117), which was a repetitive movement, with control over the level of exercise intensity. But in this study, the exercise program was designed to move the lower extremities in multiple directions and was progressed by adding the movement of the upper extremities to make the exercise more complicated and challenging, especially for the cognitive function more than walking or cycling even if it is a low intensity aerobic exercise.

With regard to the resistance exercise, this study was in concordance with several studies which suggested the resistance exercise had beneficial effects on global cognitive function (39), working memory (38) and processing speed (124) in older adults with mild cognitive impairment. Along the same line, systematic reviews (36, 37) reported that the resistance training improved global cognitive function, inhibitory control and short-term memory in the adults.

Study on time interval for earliest changes in cognitive function as a result of low intensity exercise are scarce. Previous studies using the low intensity exercise evaluated the effects of low intensity exercise on physical performance (157) or other domains of cognitive function (156, 158). For example, this study observed significant changes of inhibitory control at 2 months post-training, while a previous study found change at 3 months after low intensity aerobic exercise (156). Changes in inhibitory control at these 2 months post-training in this study, however, was only a statistical change, as the scores did not reach the level of clinical change. In comparison with the moderate intensity exercise, moderate intensity aerobic exercise or resistance exercise demonstrated change in executive function at 3 months, but the study did not identify the specific subdomains of executive function (159). Other previous studies demonstrated changes in global cognitive function after 6 weeks of either moderate intensity aerobic or moderate intensity resistance exercise (117, 160). In contrast, this study reported changes in global cognitive function at 2 months or approximately 8 weeks post-training at low intensity. Such disagreement could be due to the exercise intensity, such that moderate intensity led to the improvement in cognitive functions faster than low intensity aerobic or resistance exercise.

As for physical performances, this study was in line with a previous systematic review that found an improvement in lower limb muscle strength and balance by low intensity exercises in older adults (157). Similarly, a study by Kanda K, et al. (161) indicated that low intensity bodyweight training significantly increased in walking ability and lower extremity muscle strength in the elderly. In general, resistance exercise increased muscle strength and power more than aerobic exercise. This is because resistance training caused neuromuscular adaptations, increased in the cross-sectional area of the muscle and changed in connective tissue stiffness (162). While aerobic exercise increased mitochondrial biogenesis and capillary density. This helped the body transport and use oxygen to create energy and when aerobic exercise was performed for a long time, it helped delay the onset of muscle fatigue (163). In addition, resistance exercise for 8 weeks was found to be more likely to improve bone strength (164).

Likewise, low-intensity aerobic exercise significantly increased endurance or aerobic capacity in healthy adult (165) that exercise in aerobic level with a total duration of 120 minutes per week improved recovery and endurance performance in adults. In this study, exercise was performed 5 days per week and took 25-30 minutes to reach aerobic fitness levels in the 2nd month of training which used a total exercise duration similar to a previous study. As a result, endurance changed during the 2 months after training.

Using functional near-infrared spectroscopy, Byun and colleagues found that mild aerobic exercise in older people increased neural activation in the prefrontal cortex during Stroop Color and Word Test (SCWT) (156). The physiological mechanisms provide explanations for the impact of exercises on cognitive function. First, aerobic exercise leads to an increase in brain-derived neurotrophic factor (BDNF) (118, 122) resulted from myokines signaling which are produced from muscles during exercise (166). Increasing BDNF levels from aerobic exercise possibly result in the improvement of cognitive and executive functions. Second, aerobic exercise reduces inflammatory cytokines levels (118) that are the important predictors of mild cognitive impairment progression and enhances physical fitness in older persons with mild cognitive impairment, which is linked to higher levels of BDNF and lower levels of inflammatory cytokines, leading to the improvement of cognitive functions (167). Lastly, aerobic exercise also promotes brain oxygenation during cortical activation of several regions including prefrontal cortex, which affects executive function (168).

Resistance exercise resulted in higher levels of serum insulin-like growth factor-1 (IGF-1), which was associated with cognitive function (128, 138). Low serum IGF-1 levels had been correlated to impaired cognitive performance, especially a decrease of information processing speed in older adults (127). Therefore, improved cognitive function following resistance exercise may be explained by increasing serum IGF-1 levels.

Even though the elderly had decreased brain function, the pathophysiological decline associated with neurodegenerative conditions of the nervous system could be

delayed due to its capacity for regeneration and plasticity. In addition to increasing the neurological factors mentioned above, Exercise also increased brain volume (30) and functional connectivity (118) and improves synaptic plasticity (169), which resulted in changes in cognitive function. In addition, continued exercise might affect the levels of neurotrophic factors, which might have an influence to maintain cognitive functions during the 3-month follow-up period.

Another noteworthy point is that a statistically significant increase in TMT-B was found in the control group at 3 months after training program and during the follow-up period. This might be due to the time taken to complete the TMT-B test at baseline in the control group being relatively higher compared to the aerobic and resistance groups. When there were reassessments, participants had a better understanding of the test causing quite a lot of changes in scores. As a result, changes in TMT-B were found.

This study did not find the improvement of visuoconstructional reasoning (as measured by SDT) post exercise training. The unchanged SDT scores could be due to the fact that this test specifically assessed fine motor function and eye-hand coordination. Both aerobic and resistance exercise programs were exercises involving the large muscle groups, not targeting the fine motor skill or eye-hand coordination. As a result, no distinct improvement of fine motor function and eye-hand coordination was observed in this study.

Until now, the effects of aerobic and resistance exercises have not been directly compared in a single study, except this study. In comparison to the control group, aerobic and resistance group showed similar amount of improvement at post-training in physical performance and all cognitive domains, except visuoconstructional reasoning. We did the follow up assessment at 3-month post-training to assess whether the effect of training could be maintained. This study demonstrated that the aerobic group were able to maintain the positive impact on cognitive function in term of global cognitive function, executive function (mental flexibility and inhibitory control) and attention (processing speed), whereas the improvement of global cognitive function and mental flexibility could be maintained in the resistance group. In addition, the aerobic

group showed better improvement of inhibitory control than the control group at post-training. This could be because an aerobic exercise led to an increase in circulating neurotrophin levels and gray matter volume in the prefrontal cortex as well as the preservation of neural connection between prefrontal cortex and other regions of the brain (170, 171), which were responsible for the inhibitory control (172). Meanwhile, resistance exercise increased gray matter density in the posterior cingulate cortex and increased functional connectivity among the posterior cingulate cortex, anterior cingulate cortex and hippocampus (173), which is implicated in decision making based on action-outcomes learning and related to memory (174). In addition, the fact that aerobic exercise was different from resistance exercise might be because the nature of aerobic exercise poses were more complex movements and more rely on the coordination of the body. Moreover, participants in the aerobic group had more effort to memorize exercise moves with the exercises being changed every 2 weeks.

To assess the prolonged effect of exercise training, Law and colleagues (41) reported that cognitive improvements in people with mild cognitive impairment was sustained for 12 weeks or more after the end of the intervention with ≥ 21 hours of training durations. In the same line, this study revealed that the improvements were able to sustain after the exercise program up to 3-month, with an average total training duration of 26 hours. But there are also differences in the intensity of exercise that the previous study was of medium to high intensity while this study was of low intensity.

Clinical implications

The findings of this study highlight the importance of exercise in the older adults, as recommended by the World Health Organization (WHO) (45) and the American College of Sports Medicine and the American Heart Association (28). The older adults should do regular aerobic exercise and muscle strength training to maintain physical fitness and independence in daily life and reduce the risks of cognitive decline. According to the results of this study, both aerobic and resistance exercises had similar amount of positive impact on cognitive function. Therefore, the older adults can choose either type of exercise to fit their own health conditions and exercise preference. For

example, people at risk of cardiovascular disease may prefer aerobic over resistance exercise to prevent holding their breath which could increase the load on the cardiovascular system. Moreover, low intensity exercise is considered as an attractive exercise approach in terms of practicality and effectiveness. In addition, it encourages older people who have sedentary conditions or have limitations that are unable to exercise at a moderate intensity to still receive the benefit of exercise for improving the cognitive function. Finally, Home exercise provides the alternative for people with limited exercise space, who have travel difficulty and this mode of exercise does not require specific exercise equipment.

For the exercise program in this study, it was a low intensity exercise with a level of exhaustion less than 15 points on the Borg scale. It was performed 35 minutes per day (including a 10-minute warm-up and 10-minute cool-down), 5 days per week for 3 months and increased by 5 minutes every 2 weeks. Thereafter, it was progressed with increasing number of exercises, number of sets or repetitions and the complexity of the exercises by a physical therapist who visits every 2 weeks.

Limitations of the study

There are some limitations in this study. The average age of the older adults participated in this study was 69 years, so the results are limited and may not be generalized outside of this age group. Moreover, the results of this study only measure cognitive change, but it is not known what the corresponding neurological changes or biological changes were. Thus, in the future study, the underlying neurobiological mechanisms of low intensity aerobic and resistance exercises should be investigated in order to better understand functional and/or structural changes in the brain.

CHAPTER 6
CONCLUSION

In the present study, we revealed that low-intensity aerobic and resistance exercises at home can improve cognitive function in the areas of executive function, attention and memory domains in older persons with mild cognitive impairment, with MoCA and SCWT being the outcomes which improved earliest at 2 months after training, and the effect continued for another 3-month after the training. This results also highlight the feasibility and accessibility of low intensity exercise in the older adults which has important impact on cognition.

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APPENDIX

Exercise recording form

ID No. .....
Group .....

แบบบันทึกการออกกำลังกาย

ชื่อ ..... อายุ .....

คำชี้แจง

1. ในการออกกำลังกาย กำหนดให้ออกกำลังกาย 5 วัน/สัปดาห์
2. ให้เขียนวันที่ที่ออกกำลังกาย หรือ เขียนวันที่ทุกวันแล้วทำเครื่องหมาย “√” ว่าวันนั้นได้ออกกำลังกายหรือไม่ที่ช่อง “ออก” หรือ “ไม่ออก” โดยช่องที่เขียนว่า
   “ออก” หมายถึง ได้ออกกำลังกาย
   “ไม่ได้ออก” หมายถึง ไม่ได้ออกกำลังกาย
3. ในวันที่ออกกำลังกาย ให้บอกว่าทำได้ครบตามคู่มือหรือไม่ โดยทำเครื่องหมาย “√”ที่ช่อง “ครบ” หรือ “ไม่ครบ” โดยช่องที่เขียนว่า
   “ครบ” หมายถึง ออกกำลังกายครบตามคู่มือ
   “ไม่ครบ” หมายถึง ออกกำลังกายไม่ครบตามคู่มือ
4. บอกระดับความเหนื่อยของตนเองหลังจากออกกำลังกายเสร็จ โดยให้ตั้งแต่ 6 - 20 คะแนน
   “6” คือ รู้สึกสบาย เหมือนตอนนั่งพักเฉยๆ ไม่ได้ออกกำลังกาย
   “20” คือ เหนื่อยมากที่สุดจนทนไม่ไหว
5. ในกรณีที่ไม่ได้ออกกำลังกาย หรือ ออกกำลังกายไม่ครบระยะเวลาตามคู่มือ หรือ มีอาการ/ความผิดปกติใดๆ เกิดขึ้น ให้เขียนเหตุผลหรือปัญหาที่เกิดขึ้นในช่อง “หมายเหตุ” หรือ เขียนรายละเอียดตรงหมายเหตุด้านล่างของตาราง
6. สามารถเขียนข้อมูลอื่นๆ เพิ่มเติมได้ เช่น ชีพจร (หากใช้นาฬิกาที่ใช้วัดชีพจรได้หรือมีเครื่องวัดระดับออกซิเจนปลายนิ้วที่บอกค่าชีพจรได้)
7. หากมีอาการ หรือ ความผิดปกติใดๆ เกิดขึ้น ในขณะเข้าร่วมโครงการวิจัย สามารถติดต่อผู้วิจัย นางสาวกฤษณา ครุฑนาค เบอร์โทรศัพท์ 0817523933

การให้คะแนนระดับความเหนื่อย

คะแนน	ระดับความรู้สึก
6	
7	รู้สึกสบาย เหมือนตอนนั่งพัก
8	
9	ไม่เหนื่อย เหมือนตอนเดินไปมาในบ้าน
10	
11	เริ่มรู้สึกเหนื่อย เริ่มหายใจเร็วขึ้น แต่ไม่มีอาการหายใจติดขัด
12	
13	ค่อนข้างเหนื่อย เหมือนตอนที่เดินเร็ว แต่ยังสามารถพูดคุยได้
14	
15	เหนื่อย เหมือนตอนที่เดินเร็วมากๆ พูดคุยต่อเนื่องไม่ได้ พูดได้ไม่กี่คำต้องหยุด
16	
17	เหนื่อยมาก ไม่สามารถพูดไปด้วยในขณะเดินเร็วมากๆ ได้
18	
19	เหนื่อยที่สุด ไม่สามารถเดินเร็วมากๆ ได้ ต้องหยุดพัก
20	

แบบบันทึกการออกกำลังกาย

สัปดาห์ที่ .....1.....

วันที่	การออกกำลังกาย				ระดับ	ชีพจร		หมายเหตุ
	ออก	ไม่ได้ออก	ครบ	ไม่ครบ	ความเหนื่อย	ก่อน	หลัง	
1 พ.ย. 2564	√		√		15	75	141	มีอาการเมื่อยเล็กน้อยหลังจากออกกำลังกาย
2 พ.ย. 2564	√		√		15	72	130	
3 พ.ย. 2564		√						
4 พ.ย. 2564	√		√		13	74	128	
5 พ.ย. 2564	√		√		13	72	126	
6 พ.ย. 2564		√						
7 พ.ย. 2564	√			√	11			มีอาการปวดเข่าข้างขวาหลังจากออกกำลังกายไปประมาณ 5 นาที และมีอาการปวดข้อศอกข้างขวาเมื่อออกกำลังกายในท่าที่ต้องงอ-เหยียดศอก

หมายเหตุ

วันที่ 6 พ.ย. 2564 ตอนเช้าไปซื้อกับข้าวที่ตลาด สะดุดฝาท่อ เข่าและแขนข้างขวากระแทกพื้น ลูกพาไปโรงพยาบาลไม่มีกระดูกหัก มีแผลและรอยฟกช้ำที่เข่าและแขนบริเวณข้อศอกข้างขวา

แบบบันทึกการออกกำลังกาย

สัปดาห์ที่ .....

วันที่	การออกกำลังกาย				ระดับ	ชีพจร		หมายเหตุ
	ออก	ไม่ได้ออก	ครบ	ไม่ครบ	ความเหนื่อย	ก่อน	หลัง	

หมายเหตุ

Daily life activities recording form

ID No. .....
Group .....CONTROL.....

แบบบันทึกกิจกรรม

ชื่อ ..... อายุ .....

คำชี้แจง

1. ในหน้าแรก ให้เขียนกิจกรรมที่ทำเป็นประจำและบอกความถี่ที่ทำกิจกรรมนั้นใน 1 สัปดาห์
2. ในหน้าถัดไป ให้เขียนวันที่ทุกวันแล้วให้บอกว่าวันนั้นได้ทำกิจกรรมเหมือนเดิมหรือไม่ โดยทำเครื่องหมาย “√” ที่ช่อง “เหมือนเดิม” หรือ “ไม่เหมือนเดิม” โดยช่องที่เขียนว่า “เหมือนเดิม” หมายถึง ทำกิจกรรมเหมือนที่เขียนไว้ในหน้าแรก
   “ไม่เหมือนเดิม” หมายถึง ทำกิจกรรมไม่เหมือนที่เขียนไว้ในหน้าแรก
3. ในกรณีที่ทำเครื่องหมาย “√” ที่ช่อง “ไม่เหมือนเดิม” ให้เขียนกิจกรรมที่ไม่ได้ทำและ/หรือกิจกรรมที่ทำนอกเหนือไปจากที่เขียนไว้ในหน้าแรกที่ช่อง “กิจกรรมที่เปลี่ยนแปลงไป” และบอกสาเหตุหรืออาการที่เกิดขึ้นในช่อง “หมายเหตุ” หรือ เขียนรายละเอียดตรงหมายเหตุด้านล่างของตาราง
4. หากมีอาการ หรือ ความผิดปกติใดๆ เกิดขึ้น ในขณะเข้าร่วมโครงการวิจัย สามารถติดต่อผู้วิจัย นางสาวกฤษณา ครุฑนาค เบอร์โทรศัพท์ 0817523933

แบบบันทึกกิจกรรม

กิจกรรมที่ทำเป็นประจำ	จำนวนครั้ง/สัปดาห์	หมายเหตุ
1. กวาดบ้าน	ทุกวัน	
2. ถูบ้าน	3 - 4 วัน/สัปดาห์	
3. ซักผ้า	3 - 4 วัน/สัปดาห์	
4. รีดผ้า	1 วัน/สัปดาห์	
5. ทำกับข้าว	ทุกวัน	
6. อ่านหนังสือพิมพ์	ทุกวัน	
7. ฟังวิทยุ/ดูโทรทัศน์	ทุกวัน	
8. ไปซื้อกับข้าว/จ่ายตลาด	2 วัน/สัปดาห์	
9. พูดคุยกับเพื่อนบ้าน	ทุกวัน	
10.		

แบบบันทึกกิจกรรม

สัปดาห์ที่ .....1.....

วันที่	กิจกรรมที่ทำเป็นประจำ		กิจกรรมที่เปลี่ยนแปลงไป	หมายเหตุ
	เหมือนเดิม	ไม่เหมือนเดิม		
1 พ.ย. 2564	√			
2 พ.ย. 2564	√			
3 พ.ย. 2564		√	นัดทานข้าวกับเพื่อน และไปไหว้พระ	เดินเยอะกว่าทุกวัน กลับบ้านมามีอาการเมื่อยขาเล็กน้อย
4 พ.ย. 2564	√			
5 พ.ย. 2564	√			
6 พ.ย. 2564		√	ไม่ได้ทำงานบ้านเลย (กวาดบ้าน ถูบ้าน ซักผ้า ทำกับข้าว)	มีอาการปวดเข่าข้างขวา และข้อศอกข้างขวาเมื่อมีการขยับในท่าที่ต้องงอ-เหยียดเข่า/ศอก
7 พ.ย. 2564		√	ไม่ได้ทำงานบ้านเอง (กวาดบ้าน ถูบ้าน ซักผ้า รีดผ้า ทำกับข้าว)	มีอาการปวดเข่าข้างขวา และข้อศอกข้างขวาเมื่อมีการขยับในท่าที่ต้องงอ-เหยียดเข่า/ศอก

หมายเหตุ

วันที่ 6 พ.ย. 2564 ตอนเช้าไปซื้อกับข้าวที่ตลาด สะดุดฝาท่อ เข่าและแขนข้างขวากระแทกพื้น ลูกพาไปโรงพยาบาลไม่มีกระดูกหัก มีแผลและรอยฟกช้ำที่เข่าและแขนบริเวณข้อศอกข้างขวา

แบบบันทึกกิจกรรม

กิจกรรมที่ทำเป็นประจำ	จำนวนครั้ง/สัปดาห์	หมายเหตุ
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

แบบบันทึกกิจกรรม

สัปดาห์ที่ .....

วันที่	กิจกรรมที่ทำเป็นประจำ		กิจกรรมที่เปลี่ยนแปลงไป	หมายเหตุ
	เหมือนเดิม	ไม่เหมือนเดิม		

หมายเหตุ

Data recording form

ID No. .....

Group .....

แบบบันทึกข้อมูลของผู้เข้าร่วมโครงการวิจัย

คำชี้แจง: กรุณาทำเครื่องหมาย √ ลงในช่อง ☐ และกรอกข้อมูลลงในช่องว่างให้ตรงกับความเป็นจริง

ส่วนที่ 1 ข้อมูลทั่วไปของอาสาสมัคร

1. ชื่อ (นาย, นาง, นางสาว) ..... สกุล .....
2. ที่อยู่ปัจจุบันที่สามารถติดต่อได้ .....
   .....
3. เบอร์โทรศัพท์บ้าน ..... เบอร์โทรศัพท์มือถือ .....
4. อายุ ..... ปี (วันเกิด .....)
5. สถานภาพ ☐ โสด ☐ สมรส ☐ หย่า ☐ หม้าย ☐ แยกกันอยู่
6. การพักอาศัย ☐ อยู่ตามลำพังคนเดียว ☐ อยู่กับคู่สมรส ☐ อยู่กับบุตร หลาน ☐ อาศัยอยู่กับผู้อื่น
7. ระดับการศึกษา ☐ ไม่ได้ศึกษา ☐ ประถมศึกษา ☐ มัธยมศึกษาตอนต้น ☐ มัธยมศึกษาตอนปลาย/ปวช. ☐ อนุปริญญา/ปวส. ☐ ปริญญาตรี/ปวส. ☐ สูงกว่าปริญญาตรี ☐ อื่นๆ .....
8. อาชีพ/ลักษณะงาน ☐ ครู/อาจารย์ ☐ บุคลากรทางการแพทย์ ระบุ ..... ☐ สถาปนิก ☐ วิศวกร ☐ นักบัญชี ☐ ธุรกิจส่วนตัว ☐ งานด้านเกษตรกรรม/กสิกรรม ☐ งานราชการและรัฐวิสาหกิจ ระบุ ..... ☐ ช่างฝีมือ ระบุ ..... ☐ รับจ้าง ระบุ ..... ☐ อื่นๆ ระบุ .....

   ระยะเวลาที่ทำงานดังกล่าว (ระบุจำนวนปี) ..... ปี

   ปัจจุบันท่านยังทำงานอยู่หรือไม่ ☐ ทำงาน ระบุ ..... ☐ ไม่ได้ทำงาน

หน้าที่รับผิดชอบปัจจุบัน .....

9. มือข้างถนัด ☐ ขวา ☐ ซ้าย

10. โรคประจำตัว และ/หรือ ปัญหาทางสุขภาพ ☐ ไม่มี ☐ มี

- ☐ โรคสมองเสื่อม
- ☐ โรคทางระบบประสาท ระบุ .....
- ☐ โรคทางระบบหลอดเลือดหัวใจ ระบุ .....
- ☐ โรคทางระบบกระดูกและกล้ามเนื้อ ระบุ .....
  - รบกวนหรือจำกัดการออกกำลังกาย ☐ ไม่จำกัด ☐ จำกัด
- ☐ ความบกพร่องทางการได้ยิน ระบุ .....
  - ใส่เครื่องช่วยฟัง ☐ ไม่ใส่ ☐ ใส่
- ☐ ความบกพร่องทางสายตา ระบุ .....
  - การมองเห็น ☐ ไม่ชัด ☐ ชัด
  - ใส่แว่น ☐ ไม่ใส่ ☐ ใส่
- ☐ อื่นๆ ระบุ .....

11. เครื่องช่วยเดิน ☐ ไม่ใช้ ☐ ใช้ ระบุ .....

12. การออกกำลังกาย ☐ ไม่ออกกำลังกาย ☐ ออกกำลังกาย ระบุ .....

ลักษณะการออกกำลังกาย ระยะเวลา ..... นาที/ครั้ง ความถี่ ..... ครั้ง/สัปดาห์

13. งานอดิเรก ☐ ไม่มี ☐ มี ระบุ .....

14. ประวัติการสูบบุหรี่ ☐ ไม่สูบ ☐ เคยสูบ แต่เลิกมาแล้ว ..... ปี ☐ สูบ ระบุ จำนวน ..... มวน/วัน ระยะเวลา ..... ปี

15. ประวัติการดื่มสุรา ☐ ไม่ดื่ม ☐ เคยดื่ม แต่เลิกมาแล้ว ..... ปี ☐ ดื่ม ระบุ ความถี่ .....

16. ความดันโลหิตขณะพัก ..... mmHg

<u>ส่วนที่ 2</u> แบบสอบถามสากลด้านการมีกิจกรรมทางกาย (Global Physical Activity Questionnaire –GPAQ)

กิจกรรมทางกาย (Physical Activity)			
ต่อไปนี้จะถามท่านเกี่ยวกับระยะเวลาที่ท่านใช้ในการทำกิจกรรมทางกายรูปแบบต่างๆ ในแต่ละสัปดาห์ กรุณาตอบคำถามเหล่านี้แม้ว่าท่านไม่ได้คิดว่าท่านเป็นคนที่มีกิจกรรมการเคลื่อนไหวร่างกายมากนักก็ตาม ก่อนอื่นลองนึกถึงระยะเวลาที่ท่านใช้ในการทำงาน โดยนึกถึงงานที่ท่านต้องทำทั้งเป็นงานที่มีค่าจ้างและไม่มีค่าจ้าง การเรียน/การฝึกซ้อม งานบ้าน ทำสวนครัว/เพาะปลูก ตกปลาหรือล่าสัตว์เพื่อเป็นอาหาร การหางานทำ (และตัวอย่างอื่นๆ) ในการตอบข้อคำถามต่อไปนี้ "กิจกรรมที่มีความหนักค่อนข้างมาก" หมายถึงกิจกรรมที่ต้องออกแรงมาก ซึ่งเป็นเหตุให้ต้องหายใจถี่ขึ้นมาก หรืออัตราการเต้นของหัวใจเพิ่มสูงขึ้นอย่างมาก และ "กิจกรรมที่มีความหนักปานกลาง" หมายถึงกิจกรรมที่ออกแรงปานกลาง เป็นเหตุให้หายใจถี่ขึ้นเล็กน้อย หรืออัตราการเต้นของหัวใจเพิ่มขึ้นเล็กน้อย			
คำถาม		**คำตอบ**	**รหัส**
กิจกรรมในการทำงาน (Activity at work)			
1	งานของท่านมีส่วนเกี่ยวข้องกับ "กิจกรรมที่มีความหนักค่อนข้างมาก" จนเป็นเหตุให้ต้องหายใจถี่ขึ้นมาก หรืออัตราการเต้นของหัวใจเพิ่มสูงขึ้นอย่างมาก เช่น งานยก/แบก/หามของหนัก งานขุดดิน หรืองานก่อสร้าง ติดต่อกันอย่างน้อย 10 นาที	ใช่ 1 ไม่ใช่ 2 *(ถ้าไม่ใช่ ข้ามไปข้อ 4)*	P1
2	ท่านต้องทำ "กิจกรรมที่มีความหนักค่อนข้างมาก" ซึ่งเป็นส่วนหนึ่งของงานของท่าน สัปดาห์ละกี่วัน	จำนวนวัน ☐☐	P2
3	ท่านใช้เวลานานเพียงใดในการทำ "กิจกรรมที่มีความหนักค่อนข้างมาก" ในการทำงานแต่ละวัน	☐☐ ชั่วโมง ☐☐ นาที	P3 (a-b)
4	งานของท่านมีส่วนเกี่ยวข้องกับ "กิจกรรมที่มีความหนักปานกลาง" ที่ทำให้ท่านมีการหายใจถี่ขึ้นเล็กน้อย หรืออัตราการเต้นของหัวใจเพิ่มขึ้นเล็กน้อย เช่น เดินเร็วๆ หรือมีการยกของเบาๆ ติดต่อกันเป็นเวลาอย่างน้อย 10 นาที	ใช่ 1 ไม่ใช่ 2 *(ถ้าไม่ใช่ ข้ามไปข้อ 7)*	P4
5	ท่านต้องทำ "กิจกรรมที่มีความหนักปานกลาง" ซึ่งเป็นส่วนหนึ่งของงานของท่าน สัปดาห์ละกี่วัน	จำนวนวัน ☐☐	P5
6	ท่านใช้เวลานานเพียงใดในการทำ "กิจกรรมที่มีความหนักปานกลาง" ในการทำงานแต่ละวัน	☐☐ ชั่วโมง ☐☐ นาที	P6 (a-b)
การเดินทางไป-กลับ ที่ต่างๆ (Travel to and from places)			
คำถามต่อไป จะไม่เกี่ยวกับกิจกรรมทางกายที่เกิดขึ้นในการทำงาน ตามที่ท่านได้ตอบไปแล้ว ตอนนี้ จะขอถามท่านถึงเรื่องการเดินทางตามปกติไปยังที่ต่างๆ ในชีวิตประจำวันของท่าน เช่น ไปทำงาน ไปซื้อของ ไปตลาด ไปวัด ฯลฯ			
7	ท่านเดินทางไป-กลับ ยังที่ต่างๆ โดยการเดิน หรือขี่จักรยาน ติดต่อกันอย่างน้อย 10 นาที หรือไม่?	ใช่ 1 ไม่ใช่ 2 *(ถ้าไม่ใช่ ข้ามไปข้อ 10)*	P7
8	ในแต่ละสัปดาห์ มีกี่วันที่ท่านได้เดินหรือขี่จักรยานไป-กลับ ยังที่ต่างๆ ติดต่อกันอย่างน้อย 10 นาที?	จำนวนวัน ☐☐	P8
9	ในแต่ละวัน ท่านใช้เวลาเพื่อการเดิน หรือขี่จักรยานนานเพียงใด?	☐☐ ชั่วโมง ☐☐ นาที	P9 (a-b)

กิจกรรมนันทนาการ (Recreational activities)			
คำถามต่อไป จะไม่เกี่ยวกับกิจกรรมในการทำงานและการเดินทางที่ท่านได้ตอบไปแล้ว ตอนนี้ จะถามท่านถึง กีฬา การฝึกเพื่อเสริมสร้างความแข็งแรง และกิจกรรมนันทนาการ(กิจกรรมยามว่าง)			
10	ท่านได้เล่นกีฬา หรือฝึกหนักเพื่อเสริมสร้างความแข็งแรง หรือทำกิจกรรมนันทนาการยามว่าง ที่ต้องออกแรงหนักค่อนข้างมาก จนทำให้ท่านต้องหายใจถี่ขึ้น หรือหัวใจเต้นเร็วขึ้นอย่างมาก เช่น วิ่ง หรือเล่นฟุตบอล ติดต่อกันอย่างน้อย 10 นาที	ใช่ 1 ไม่ใช่ 2 *(ถ้าไม่ใช่ ข้ามไปข้อ 13)*	P10
11	ท่านได้เล่นกีฬา หรือฝึกหนักเพื่อเสริมสร้างความแข็งแรง หรือทำกิจกรรมนันทนาการยามว่าง ที่ต้องออกแรงหนักค่อนข้างมาก สัปดาห์ละกี่วัน?	จำนวนวัน ☐☐	P11
12	ท่านได้เล่นกีฬา หรือฝึกหนักเพื่อเสริมสร้างความแข็งแรง หรือทำกิจกรรมนันทนาการยามว่าง ที่ต้องออกแรงหนักค่อนข้างมาก นานเท่าไรในแต่ละวัน?	☐☐ ชั่วโมง ☐☐ นาที	P12 (a-b)
13	ท่านได้เล่นกีฬา หรือฝึกเพื่อเสริมสร้างความแข็งแรง หรือทำกิจกรรมนันทนาการยามว่าง ที่ออกแรงปานกลาง ทำให้ท่านหายใจถี่ขึ้น หรือหัวใจเต้นเร็วขึ้นเล็กน้อย เช่น เดินเร็ว ขี่จักรยาน ว่ายน้ำ ฟุตบอล ติดต่อกันอย่างน้อย 10 นาที	ใช่ 1 ไม่ใช่ 2 *(ถ้าไม่ใช่ ข้ามไปข้อ 16)*	P13
14	ท่านได้เล่นกีฬา หรือฝึกเพื่อเสริมสร้างความแข็งแรง หรือทำกิจกรรมนันทนาการยามว่าง ที่ออกแรงปานกลาง สัปดาห์ละกี่วัน?	จำนวนวัน ☐☐	P14
15	ท่านได้เล่นกีฬา หรือฝึกเพื่อเสริมสร้างความแข็งแรง หรือทำกิจกรรมนันทนาการยามว่าง ที่ออกแรงปานกลาง นานเท่าไรในแต่ละวัน?	☐☐ ชั่วโมง ☐☐ นาที	P15 (a-b)
พฤติกรรมการนั่ง (Sedentary behavior)			
ต่อไป เป็นคำถามเกี่ยวกับการนั่งๆ นอนๆ ทั้งที่บ้าน หรือที่ทำงาน การเดินทางไป-กลับยังที่ต่างๆ รวมถึงเวลาที่ใช้ในการนั่งโต๊ะทำงาน นั่งคุยกับเพื่อน นั่งอยู่ในรถยนต์ รอประจำทาง รอไฟ นั่งอ่านหนังสือ นั่งเล่นไพ่ นั่งดูโทรทัศน์ แต่ไม่รวมถึงเวลานอนหลับ			
16	ในแต่ละวัน ท่านใช้เวลาไปกับการนั่งๆ นอนๆ นานเพียงใด?	☐☐ ชั่วโมง ☐☐ นาที	P16 (a-b)

ID No. .....
ครั้งที่ .....
วันที่ .....

ส่วนที่ 3 แบบบันทึกคะแนนการทดสอบ *Cognitive performance outcomes*

MoCA Total score .....

TMT Part A ..... วินาที

Part B ..... วินาที

DST Forward .....

Backward .....

SCWT Word (W) .....

Color (C) .....

Color-word (CW) .....

Interference score = CW - [(W x C)/(W + C)]

Interference score .....

SDT Total score .....

Physical performance outcomes

TUG Manual .....

Use hands to push up ☐ ไม่ใช้ ☐ ใช้

Gait assistive devices ☐ ไม่ใช้ ☐ ใช้

ระบุ .....

6MWT ระยะทาง .....

Gait assistive devices ☐ ไม่ใช้ ☐ ใช้

ระบุ .....

จำนวนครั้งที่หยุดพัก .....

ระยะเวลาที่หยุดพัก .....

30-secind chair stand .....

30-second arm curl .....

Aerobic exercise program (example)

เดินเร็ว หรือ ย่ำเท้าอยู่กับที่ (ยกขาสูงระดับสะโพก)

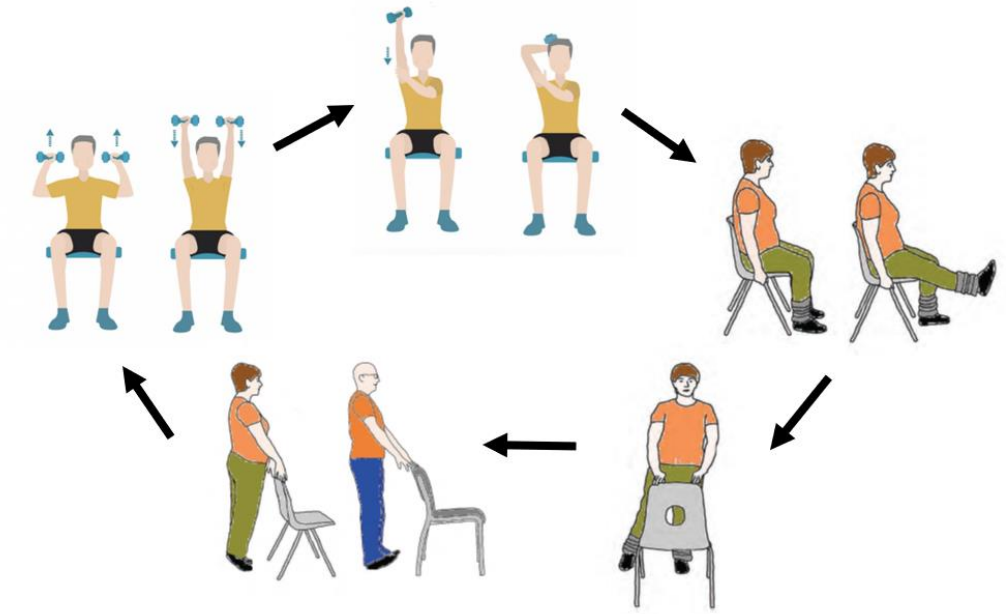
นำมือแตะเข่าสลับซ้าย-ขวา

ชกแขนไปทางด้านบนสลับซ้าย-ขวา

ชกแขนไปทางด้านหน้าสลับซ้าย-ขวา

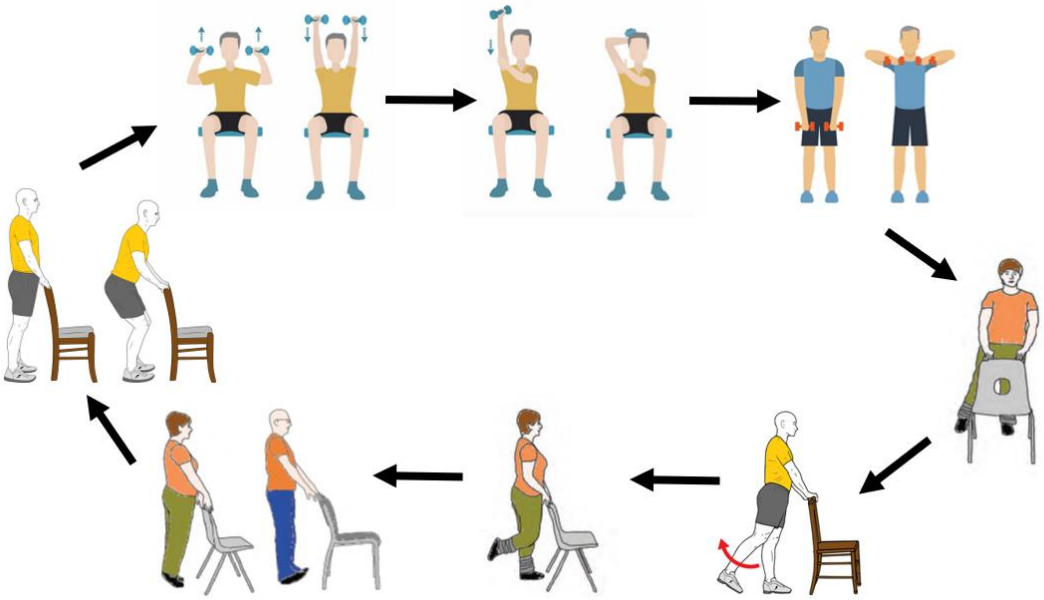
ชกแขนไปทางด้านข้างสลับซ้าย-ขวา

Resistance exercise program (example)



แขน: 15 ครั้ง/ท่า พัก 30 – 60 วินาที ระหว่างท่า ทำทั้งหมด 3 รอบ

ขา: 10 ครั้ง/ท่า พัก 30 – 60 วินาที ระหว่างท่า ทำทั้งหมด 3 รอบ



แขน: 15 ครั้ง/ท่า พัก 30 – 60 วินาที ระหว่างท่า ทำทั้งหมด 3 รอบ

ขา: 12 ครั้ง/ท่า พัก 30 – 60 วินาที ระหว่างท่า ทำทั้งหมด 3 รอบ

Source: University of Otago, Otago Medical School. Otago Exercise Programme to prevent falls in older adults: A home-based, individually tailored strength and balance retraining programme. 2003.

Source of Images: Available from: https://californiamobility.com/21-chair-exercises-for-seniors-visual-guide/, https://evelo.com/blogs/learn/exercise-guide-for-seniors and https://www.workoutsprograms.com/workouts/

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