The Effect of Structured Limbs Exercise as a Treatment to Improve the Psychomotor Speed in Older Adults with Mild Cognitive Impairment

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The Effect of Structured Limbs Exercise as a Treatment to Improve the Psychomotor Speed in Older Adults with Mild Cognitive Impairment

by

Jiang Hao

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I, Jiang Hao, hereby declare that I am the sole author of the thesis and the material presented in this thesis in my original work except those indicated in the acknowledgement. I further declare that I have followed the Institute's policies and regulations on Academic Honesty, Copy Right and Plagiarism in writing the thesis and no material in this thesis has been published or submitted for a degree in this or other universities.

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Jiang Hao

April 2016

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ABSTRACT

The Effect of Structured Limbs Exercise as a Treatment to Improve the Psychomotor Speed in Older Adults with Mild Cognitive Impairment

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Nowadays, maintaining the physical and mental health of older adults has become a critical topic worldwide. Alzheimer's disease (AD) is the most common type of dementia, and it is a type of chronic neurodegenerative disease that severely impairs a person's cognitive function, thus hindering the patient's self-care ability and causing psychological behavior disorder (Gubrium & Lynott, 1987). Mild cognitive impairment (MCI), also known as early dementia or isolated memory impairment is a transitional state between the normal ageing process of the brain and early dementia. Psychomotor speed (PS) and the physical and cognitive functions of older adults are inseparable. If older adults receive treatment during early-stage MCI, the occurrence of AD can be deferred to its fullest, ensuring the quality of life of older adults with advancing age. Therefore, we used PS elevation as the basis for designing the form, content, and intensity of the physical exercise, investigated the importance of limb exercise (aimed at PS elevation) on MCI, and explored the effect of limb exercise for improving the cognitive function of MCI patients.

The demographic and clinical data of the research subjects show that the average age of the subjects was 65.22 ± 3.27 years and sex ratio was even. 22 MCI patients in the training intervention group additionally completed a 10-week structured limbs exercise training program. Finally, complete data were collected from 41 participants: 20 in the limb training group and 21 in the waiting-list control group. This study used SPSS Version 18 to organise and analyse the data. In summary, the limb exercise training intervention contributed to a more significant improvement in the MCI patients' psychomotor exercise speed.

Results indicated that the MCI patients achieved more significant improvements in their FTT, PPT and all dimensions of the MoCA scores. The power values of the alpha and beta EEG waves in all brain areas of MCI patients increased more significantly, implying that limb exercise training positively influenced the patients' brain function with intervention after MCI patients.

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LIST OF ABBREVIATIONS

AD	Alzheimer’s disease
WHO	World Health Organization
ADI	Alzheimer Disease International
MCI	Mild cognitive impairment
PS	Psychomotor speed
MBF	Miami Brain Fitness
EEG	Electroencephalogram
aMCI	amnestic MCI
naMCI	nonamnestic MCI
MMSE	Mini-Mental Status Examination
CSF	Cerebrospinal Fluid
ERP	Vent-Related Potential
PET	Positron Emission Tomography
SPECT	Single Photon Emission Computed Tomography
MRI	Magnetic Resonance Imaging
ADL	Activities of Daily Living
MoCA	Montreal Cognitive Assessment
FTT	Finger Tapping Test
PPT	Purdue Pegboard Test
QMM	Quantitative Motor Measures
LSD	Least significant difference
BDNF	Brain-Derived Neurotrophic Factor

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CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 Background

1.1.1 Current Epidemiological Situation of Dementia

In the twenty-first century, population ageing is a global phenomenon attracted particular attention from the international community. It is a critical problem with affects the global strategic and socioeconomic development. Statistics have indicated that older adults aged >60 years accounted for 11% of the world population in 2000 and estimated that the population of older adults will double and account for 22% of the world population by 2050 (WHO, 2013). Therefore, maintaining the physical and mental health of older adults has become a critical topic worldwide. Alzheimer's disease (AD) is a type of chronic neurodegenerative disease that severely impairs a person's cognitive function, thus hindering the patient's self-care ability and causing psychological behavior disorder (Gubrium & Lynott, 1987). After the onset of AD, patients experience disorder in their cognitive activities (problems with memory, language, thinking, calculation, and comprehension) and in comprehensive judgment, which involves higher functions of the nervous system, thus causing a gradual decline in the ability to manage events in daily life and in abilities required for work and social interactions. A gradual loss of self-care ability increases the patient's dependence on homecare and healthcare personnel (Allen & Burns, 1995). AD can occur at any age but often occurs in people aged 60–70 years, with increased age increasing the risk of AD. Although medication can postpone the developmental process of dementia, an effective treatment is lacking (Alberici et al. 2014). According to the WHO in 2012, approximately 35.6 million people were affected by dementia, with an annual increase of 4.6 million cases. Approximately 65.7 million people are estimated to be affected by dementia by 2030 and more than 100 million by 2050; 58% of those affected will be from developing countries (WHO, 2012). AD is the most common type of dementia, and patients with AD account for 60%¬–70% of the patients with dementia (ADI, 2008; WHO, 2012), with the number of AD diagnoses increasing yearly. If AD prevention and interventions are not timely and effective, the number of AD patients will double within decades (ADI, 2012).

The United States has approximately 4.5 million AD patients, and statistics indicate that the number will increase to 14 million by 2030 (Graff, 2014; Winchester et al., 2013; Yu et al., 2008). AD accounts for the sixth-highest mortality rate in the United States and has a survival time of 4–20 years. The average survival time is 8 years for patients of various age and health conditions (Belbin et al., 2011; Hollingworth et al., 2011). AD affects approximately 500,000 people in England and is the most common type of dementia (National Health Service, 2015). The average medical expenditure on AD patients in England amounts to £4091 per person-year, accounting for approximately 12% of the total costs of physical illness and community care. The United Kingdom must pay approximately £2 billion for AD patient treatment and care per year (Morris et al, 2015). In Hong Kong, the number of AD patients continues to rise because of an increasing ageing population. According to a survey released by the Hong Kong Alzheimer's Disease Association, Hong Kong had 103,433 AD patients in 2009, with the total increasing substantially each year. Data released by the Alzheimer's disease International, ADI-China Committee indicated that the prevalence of dementia in older adults aged >65 years is 6.6% and that it approximately doubles with every 5-year increase in age; in other words, the prevalence of dementia in those aged >80 years is more than 22%. In addition, by the middle of the twenty-first century, the elderly population will increase to 400 million; the patients with dementia will number approximately 20 million, and the number of patients with dementia will increase by a ratio of 336% in China (ADI-China, 2012). China has approximately 9 million AD patients currently, and the number is increasing substantially at a rate of more than 300,000 cases per year. The prevalence of AD in older adults aged >80 will achieve 30% in China; in other words, one of every three people will be affected by AD (WHO, 2012), and 92% of patients will receive no professional medical care or treatment (Chen, 2014). However, thus far, despite AD becoming a global health crisis, no country (neither developed countries nor developing countries) has been capable of countering this considerable crisis. Existing medications cannot cure AD, and thus the economic burdens and social problems induced by this disease are gradually increasing, influencing AD patients and their families and producing immeasurable impacts on overall social development. The number of AD patients in China exceeds that in any other country, and the associated social problems are more severe. With the proportion of the ageing population in China continually increasing, problems related to old-age security and medical care are also increasing. Because AD is one of the most critical public health problems resulting from an ageing population, AD prevention has become a topic of focus in current medical studies.

1.1.2 Mild Cognitive Impairment and Alzheimer's disease

Mild cognitive impairment (MCI), also called incipient dementia or isolated memory impairment, is a transitional stage between normal brain aging and early stage dementia (particularly for Alzheimer's disease). People with MCI are affected by symptoms of memory impairment at an earlier than normal stage, but their memory functioning remains satisfactory without having any serious impact on their daily lives or activities (Petersen et al., 1999). With an increase in age, older adults commonly experience declining cognitive function to some extent, a trend particularly evident in the decline of memory function (Petersen, 2011). MCI is a disease that occurs in AD development. Although the state of cognitive impairment is greater than that expected in the normal ageing process, the impairment has not yet satisfied the diagnostic criteria of AD (Grothe et al, 2012). AD in its initial stage is frequently associated with MCI, and, within a few years, cognitive impairment and functional disorder gradually develop (Arai, 2005). Therefore, MCI accelerates the risk of AD developing; in particular, memory impairment is the major symptom in patients with MCI.

Gauthier, Reisberg, and Zaudig reported that the prevalence of MCI patients developing dementia is 10%–15% and that some MCI patients remain in a stable state for a certain period. If MCI patients do not receive timely treatment, 50% of them will become AD patients within 5 years (2006). The prevalence of normal older adults developing dementia is only 1%–2% (Li et al, 2012). In fact, the risk of MCI patients developing AD is 10 times higher that of normal older adults, clearly indicating the priming effect of MCI on AD onset. Current prevention studies on AD have shifted from the clinical phase to examining the preclinical phase because MCI prevention and reduction in older adults (aged ≥65 years) are particularly crucial. Early MCI diagnosis and intervention are critical to preventing development of AD.

1.1.3 Current Research on Mild Cognitive Impairment

MCI is a clinical state between normal ageing and dementia and particularly refers to declining cognitive function that does not correspond with the patient's age and educational status, that does not yet affect the patient's daily life, and that does not yet satisfy the clinical diagnostic criteria for dementia. Older adults experience some extent of declining cognitive function with increasing age, with declining memory function being particularly evident. Only one of 100 people demonstrates no decline or a no evident decline in cognitive function (Petersen, 2011). In the 1990s, Petersen et al. proposed the concept of MCI, specifying the following identification criteria: (1) A decline in the subjective report of memory, as proven by people familiar with the person; (2) An impairment in memory function (or in other cognitive functions) inconsistent with the person's age and educational attainment, as indicated by an objective test; (3) Relatively favourable cognitive function overall; (4) No effect exhibited on daily activities; (5) No signs of dementia (Petersen et al., 1999).

Considerable difference exists in the global prevalence of MCI because of heterogeneity of diagnostic methods and differences in country and region, age of the population, and educational attainment. Research data obtained since 2010 indicate that MCI prevalence in different countries and among different populations is 16.0%–39.1% (Petersen et al, 2010; Sachdev et al, 2012). A recent meta-analysis of MCI indicated that MCI prevalence in older adults in China is 12.7% (95% confidence interval = 9.7%–16.5%) and that MCI prevalence in the western region (14.7%) is higher than that in the eastern region (9.6%) (Nie et al, 2012). MCI prevalence increases with age (Tervo et al., 2004). A meta-analysis (Nie et al., 2011) determined that MCI prevalence in China of older adults aged 60, 65, 70, 75, and 80 years was 12.7%, 17.1%, 23.8%, 32.4%, and 43.7%, respectively. Although the data provided by an epidemiological survey differed, it is irrefutable that numerous older adults have MCI. Consequently, the increasing ageing population has heightened the focus of studies on MCI (Petersen et al., 2009).

Previous studies have clearly identified the intervenable and nonintervenable factors causing MCI. Among them, the protective factors incorporate attainment in higher education, cognitive stimulating activities, physical exercise, dietary factors (monounsaturated or polyunsaturated fatty acids), and eating habits such as the Mediterranean diet. The risk factors involved advanced age, the apolipoprotein E ε4 gene, male sex, low educational attainment, a vascular setback (diabetes, hypertension, obesity, high cholesterol, or cigarette smoking), cardiovascular disease (coronary heart disease, atrial fibrillation, heart failure, or cerebrovascular disease), systemic inflammatory response, depression, and anxiety disorder (Roberts et al, 2012; Li et al, 2012; Debette et al, 2011; Abner, 2012).

Cognitive function impairment and psychological and behavioural disorders are the main problems experienced by MCI patients. Previous studies have indicated that MCI patients demonstrate some extent of decline in numerous cognitive functions such as memory, execution ability, sense of direction, visual–spatial ability, language ability, and thinking ability, with memory function impairment being the most common (Collie & Maruff, 2000; Vogel et al, 2004). Both cognitive function impairment and psychological and behavioural disorders are associated with MCI patients. Epidemiological survey data based on many communities in the United States indicated that 43.1% of MCI patients had symptoms related to psychological behaviour, with 28.7% of them satisfying clinical diagnostic criteria. The primary symptoms experienced by MCI patients were problems associated with depression, irritability, apathy, sleep disorders, and agitation/aggression (Lyketsos et al., 2002; Lopez et al., 2005). In addition, some studies have indicated that MCI patients with neuropsychiatric problems experience greater cognitive impairment than do patients with no evident psychological and behavioural disorders (Feldman et al., 2004).

Numerous studies have verified that MCI is associated with brain and cognitive plasticity; thus, intervening in the development of cognitive impairment can effectively postpone declining cognitive function and prevent MCI from developing into AD (Li et al, 2011; Simon et al, 2012). Currently, MCI intervention strategy comprises nondrug intervention (physical training, cognitive intervention, and psychological intervention) and drug intervention (Rojas & Cameron, 2012; Teixeira et al, 2012; Lövdén et al, 2011; Joosten et al, 2010). To prevent and reduce drug side effects, most studies have recommended that MCI treatment focus primarily on nondrug intervention (Daviglus et al, 2010). Previous studies have verified that intervening in MCI development is effective; however, studies have examined only cognitive intervention. The WHO indicates that health is a comprehensive concept comprising physical, psychological, and social adaptation. Therefore, a comprehensive intervention involving these three aspects within an expected period would be more effective than an intervention involving only a singular aspect.

1.1.4 Psychomotor Speed and Mild Cognitive Impairment

According to Chen (1992), psychomotor is defined as an exercise effect subordinated to mental and brain history and can be divided into two types: (1) In neuropsychology, psychomotor is mainly associated with sensorimotor activities, which involve the exercise effect directly aroused by sensory stimulation; (2) In medical psychology and abnormal psychology, psychomotor mainly refers to concept exercise and incorporates an exercise effect generated by the mind. In a person's mental activity, the two types of psychological activity frequently appear simultaneously; therefore, in this study, psychomotor activity is used to explain this phenomenon (Chen, 1992). Psychomotor speed (PS) is a sensitive index used to measure psychomotor function (Foster et al, 2011) and is controlled by the brain's basal ganglia, which comprises the caudate nucleus, putamen, nucleus accumbens, globus pallidus, subthalamic nucleus, and substantia nigra (Tang, 2008). The pathology of neurodegenerative disease (e.g., Parkinson's disease) indicates a considerable amount of degeneration in the dopamine neurons of the substantia nigra in the basal ganglia, thus causing patients to have symptoms of bradykinesia, loss of motor skill, and resting tremor.

A psychomotor test is a method for measuring the central function of the brain's reaction speed and accuracy when the brain performs simple or complicated actions after receiving stimulation. Early studies on PS measurement selected only simple reaction time and choice reaction time (Pate & Margolin, 1994; Baddeley et al., 2001; Levinoff et al., 2005); however, these two are only a part of PS behaviour. According to Sobin and Sackeim (1997), in their observation of the psychomotor characteristics of patients with depression, four levels of PS can be observed and measured: gross motor activity, body movements, speech, and motor response time. Therefore, PS not only entails the speed for information processing but also the speed of overall body activity and activity requiring delicacy (Buyukdura et al., 2011). Driving is an example. The so-called "delicate" motor skills involve dexterity and coordination. Many studies have used neuropsychological testing to measure hand dexterity and hand–eye coordination to reflect the functional basis of slow PS (Mathiowetz et al., 1985). Previous studies have employed quantified response action and divided it into two parts, namely course of cognition (the time spent on decision making) and course of action (the time spent on action response), for measuring PS (Strauss et al., 2006).

PS with an uncoordinated response indicates some dysfunction in the motor response of a person's central nervous system, such as the dysfunction in action execution function that early-stage AD patients have. Pignatti, Rabuffetti, and Imbornone (Pignatti et al, 2005) found that, in the current psychological testing of selective visual attention in AD patients, a slowing of task execution speeds, declining of programming ability, and increasing of repeated actions all cause AD patients to demonstrate less favorable performance than normal older adults in both the quantity and quality of the tasks completed. When PS and low-level attention first become impaired in subcortical dementia, selective attention and an increased level of separation are the first symptoms to appear, with a more evident fracture to be exhibited in AD. MCI patients are in the preclinical stage of AD and their PS demonstrates characteristic changes. Block design, a neuropsychological test partially obtained from the Wechsler intelligence scale, is related to spatial perception and executive function and is primarily used for pattern recognition and for examining the structural capacity of cognitive function (Shah & Frith, 1993). Li, Bi, and Ciou employed block design and a digit span test to compare the psychomotor characteristics of MCI patients with those of normal older adults. The results indicated that several cognitive functions in MCI patients had declined, that patient performance on aspects of delayed recall, visual–spatial skill (pattern recognition and structural capacity), and operating speed were similar to the psychomotor characteristics of patients with early AD, and that evident signs of slow PS were exhibited (Li et al, 2007).

Slow PS is exhibited in multiple forms, with the external signs of its performance mainly involving slowness in basic movements (i.e., whole body activity, facial activity, and activity requiring delicacy performed by other body parts), slowness and incoherence in language, and decline in calculation ability. People with a severe slowness in PS may experience decline in daily activities (e.g., bathing, getting out of bed, dressing, and answering phone calls) and may be incapable of making prompt decisions when encountering unexpected incidents (MBF, 2008). MCI patients have an evident decline or deficiency in their ability to perform dual tasks (Makizako et al, 2013). In addition, slow PS is particularly evident in some patients with a mental illness such as depression (White et al., 1997; Gligoroska et al., 2010) or schizophrenia (Pier et al., 2004). Studies have indicated that depression is one risk factor for people developing dementia and MCI and that the cognitive function symptoms exhibited in depression and MCI are highly consistent with the symptoms exhibited in slow PS (Monastero et al., 2009; Dal Forno et al., 2005). Therefore, the present study used PS elevation as the basis for establishing a set of ground breaking intervention strategies for delaying and preventing MCI patients from experiencing continuous cognitive function impairment.

1.1.5 Relationship between Physical Exercise and Mild Cognitive Impairment

Physical exercise plays a crucial role in promoting physical health (Kotecki, 2014). Numerous studies have verified that physical exercise has a protective effect on cognitive function during later life (Anderson et al, 2010; Ang et al., 2010; Kim et al., 2011); in addition, animal studies have also provided positive evidence regarding this topic (García et al., 2011). Lam (2012) verified the effect of Taijiquan and stretching exercise on cognitive function and found that, 1 year after the experiment, the extent of decline in cognitive function in the Taijiquan group was minor compared with the stretching group, thus indicating that regular exercise, particularly physical and mental training combined with cognitive load and coordination-ability training, has a protective effect on the cognitive function of older adults. Davey (1973) employed theory regarding the short-term interaction of exercise and cognitive function and verified that moderate-intensity exercise can improve cognitive function more than mild- or strong-intensity exercise and can improve the speed of processing information, memory, and attention. The theory underlying exercise–cognitive interaction with delayed stimulation states that a reasonable and specific distribution of cognitive load during exercise training enables the cognitive function to achieve a more favourable state than that which occurs in exercise–cognitive interaction with low-level motor stimulation; in addition, an overly high level of motor stimulation disturbs neuron stability, thus preventing improved cognitive function from being maintained (Dietrich & Audiffren, 2011). Knab (2012) considered that, when the factors of demography and lifestyle are set, the frequency of performing aerobic exercise is clearly associated with mental state, quality of life, and perceived pressure from other adults. Consequently, no unified law is exerted in the effect of exercise form, intensity, and frequency on the cognitive function of older people. In 2007, the American College of Sports Medicine and American Heart Association first released an exercise guide for improving and maintaining the physical health of older adults. Generally, 30 minutes of moderate-intensity aerobic exercise performed 5 times per week is beneficial for physical health. In addition, strength and flexibility training should also be performed for a minimum of 10 minutes per session and more than 2 times per week.

Regarding the substantial effect of exercise on cognitive function, the most evident effect is exerted on the execution and control processes, which involve project and schedule planning, working memory, suppression, and the management of multiple tasks (Colcombe et al, 2004). Relevant neurophysiological studies on the effect of the protective mechanism of physical exercise on cognitive function have indicated that, from the perspective of cognitive neuroscience, exercise can increase the release of neurotransmitters (Perry, 2013; Lin & Kuo, 2013), slightly adjusting neuron structure and secreting growth factor in various brain tissues (Huang et al., 2014). In particular, when performing aerobic exercise requiring strength and flexibility, activity in the prefrontal lobe, parietal lobe, and temporal lobe of the brain instantly increases, enabling exercisers to elevate their attention control and execution abilities continually (Kramer et al, 2006). Moderate-intensity exercise of large muscle groups can elevate the oxygen intake, delivery, and utilization of exercisers, as well as stimulating the pituitary gland to secrete β-Endorphin, a favorable type of physiological sedative; thus, the ability of the central nervous system to react can be elevated, and the body's tolerance of external stimuli can be strengthened (Mehl, et al, 1999). During exercise, the nervous system generates micro-electrical stimulation, a type of stimulation that can ease muscle tension and depression, relax the brain cortex, mitigate physical pain and psychological stress, and elevate PS (Hartmann et al, 2005). Exercise exerts a neuroprotective effect for neurodegenerative diseases (Gregory et al., 2012). Simultaneously, exercise is an efficient, economic, and easily available intervention strategy that has few side effects and can substantially reduce the rate of cognitive decline in patients with vascular cognitive impairment (Liu-Ambrose et al, 2010).

Relatively few studies have examined the effect of physical exercise on the cognitive function of MCI patients. Two studies that are frequently quoted by other studies have summarized five types of clinical trial research on exercise and cognitive function in MCI patients (Lautenschlager, et al, 2010; Teixeira et al., 2011). These studies indicated that moderate-intensity exercise (e.g., walking) can elevate cognitive function related to the execution ability, memory, and attention of MCI patients, particularly for female MCI patients. Simultaneously, high exercise participation and compliance enable MCI patients to exhibit evident improvement in cognitive function. Exercise training can improve the physical function of older adults, and standardised exercise training is useful for clinicians who promote the MCI intervention strategy and apply it to members of communities (Elsawy & Higgins, 2010). Of the studies examining the effect of exercise training on cognitive function, studies have investigated the relationship between exercise training and the cognitive function of older adults, have traced the results of exercise training on cognitive improvement in older adults, and have meticulously explored the effect of varying exercise intensity, frequency, and duration and of changing training methods on cognitive function in older adults. However, the studies have mostly entailed the effect of intervention on normal older adults, whereas no study has focused particularly on older adults with MCI in urban communities. In addition, the exercise training methods employed in these studies were singular, and the conventional content design of the exercise training frequently neglected PS, which is a sensitive indicator for assessing cognitive function.

1.2 Statement of the Problem

PS and the physical and cognitive functions of older adults are inseparable. However, previous empirical studies on the effect of physical exercise intervention have frequently neglected the operation and control of PS. In particular, with an increase in the number of ageing people worldwide, more attention has been focused on the health of older adults. The increasing age of older adults reduces their physical and cognitive functions in varying degrees. A decline of physical function may cause older adults to experience falls, the disuse of muscle function, and long periods of being bedridden and even death.

MCI is a clinical state that can occur between normal ageing and dementia and refers in particular to a state of declining cognitive function that does not correspond with a person’s age and educational status, does not yet affect daily living, and has not yet satisfied the clinical diagnostic criteria for dementia. Older adults typically experience some degree of declining cognitive function with increased age, particularly a decline in memory function. For the first time in 2012, China conducted an epidemiological study on MCI and its pathogeny in older adults living in urban communities and rural areas (Jia & Wu, 2012). This epidemiological investigation on dementia is the only large-scale study in China since the beginning of the twenty-first century to involve many regions and focus on community groups. The survey results indicated that approximately 6 million older adults aged >65 years had dementia and

2.4 million had MCI. The MCI prevalence in China of older adults aged 60, 65, 70, 75, and 80 years was 12.7%, 17.1%, 23.8%, 32.4%, and 43.7%, respectively (Nie et al., 2011), thus indicating that numerous older adults had MCI. An accelerating ageing process has induced many studies to focus on MCI. The early employment of an effective measurement for MCI interventions could defer the decline of physical and cognitive functions in older adults.

Recently, studies have been exploring the critical effect of physical exercise on improving cognitive ability and exerting brain function. Numerous studies have verified that physical exercise has a protective effect on cognitive function in later life (Anderson et al., 2010; Ang et al., 2010), and animal studies have also provided positive evidence regarding this topic (García et al., 2011). Varying exercise form, intensity, and frequency lead to different effects on the cognitive function of older adults (Davey, 1973; Knab, 2012). Exercise can promote blood vessel dilation, improve hemodynamic responses, correct neurophysiological disorders, and in turn increase the adaptability of the central nervous system. The effect of exercise intervention on the cognitive function of older adults depends on the complexity of the exercise task and the associated extent of cognitive demand. The potential effect between long-term exercise training and cognitive function centers on training ageing functions and life skills (Pesce, 2012). Opportune exercise training has a crucial effect on the cognitive function of older adults. Physical exercise is an efficient, economic, and accessible intervention strategy involving the theoretical basis that exercise can improve blood circulation and oxygen supply to the brain and thus enable brain tissues to acquire more nutrition for brain function maintenance (Cotman & Berchtold, 2002). In addition, the physical condition of older adults is closely related to the degeneration of hippocampal brain tissue; yet, exercise can induce fibroblast growth factor in the hippocampus, increase hippocampal volume in older adults, and in turn change the brain structure, strengthen the vitality of neurons, and defer cognitive function degeneration in older adults. Therefore, exercise has a definite guiding value for MCI prevention (Erickson et al., 2011).

MCI patients are in the preclinical stage of AD, during which their PS levels also undergo characteristic changes. These patients demonstrate some extent of decline in a number of cognitive functions and their performance in delayed recall, visual–spatial ability (pattern recognition and structural ability), and speed operations are similar to the psychomotor characteristics of patients with early AD. MCI patients also demonstrate clear signs of PS slowness (Li et al, 2007). Previous studies have verified the positive relationship between limb exercise and PS, as the two can exhibit a positive effect on a person's attention, execution ability, and physical coordination (Marmeleira et al., 2013; Shigematsu et al., 2008). Because physical exercise exerts a positive effect on cognitive and brain functions and limb exercise can elevate PS, we suggest that limb exercise may be effective in deferring MCI. Consequently, we endeavored to determine the importance of limb exercise aimed at PS elevation on MCI and the effect of limb exercise on improving cognitive function in MCI patients.

1.3 Purpose of the study

The cause and prevention of AD is complex; in fact, the cause of the disease remains unclear. Currently, no treatment prevents or reverses the course of the disease, and only a few methods can be employed to temporarily ease and improve AD symptoms (WHO, 2012). Numerous studies have verified that MCI is associated with brain and cognitive plasticity; thus, intervening in the development of cognitive impairment can effectively postpone declining cognitive function and prevent MCI from turning into AD. Currently, MCI intervention strategy comprises drug intervention and nondrug intervention (physical training, cognitive intervention, and psychological intervention). To prevent and reduce drug side effects, most studies have recommended that MCI treatment focus primarily on nondrug intervention. For example, a meta-analysis of MCI cognitive intervention (Li et al, 2011) and studies conducting systematic reviews (Simon et al, 2012) have all indicated that cognitive intervention has a promoting effect on the objective assessing and subjective reporting of the comprehensive cognitive ability of MCI patients. However, previous studies have seldom reported the effect of MCI intervention in a no cognitive domain such as physical training. Relatively few studies have examined the effect of physical exercise on the cognitive function of MCI patients. Of the studies exploring the effect of exercise training on cognitive function, studies have investigated the relationship between exercise training and the cognitive function of older adults in a cross-sectional design, followed up the effect of exercise training on cognitive improvement in older adults in a longitudinal design, and meticulously explored the effect of different exercise characteristics such as intensity, frequency, time, and training method on older adults' cognitive function. However, the studies typically examined the effect of interventions on older adults in general settings, whereas no studies have particularly focused on older adults with MCI in urban communities and nursing homes. In addition, the exercise training methods employed in these studies were singular, and the conventional content design of the exercise training frequently neglected PS, which is a sensitive indicator for assessing cognitive function. The research objectives were divided into the following three points:

a. To aimed at confirming the importance of limb exercise, which was aimed at PS elevation, on MCI and explored the effect of limb exercise on cognitive function improvement in MCI patients.

b. To specify the connection between the PS and cognitive function of MCI patients and in turn to enrich theoretical research on MCI diagnosis and perfect the standard process for MCI screening.

c. To verify the improving effect of the limb exercise project, this aims at elevating PS, on the cognitive function of MCI patients and thus provide a more extensive basic research regarding treatment for preclinical AD.

d. Evaluations of the PS, cognitive level, and electroencephalogram (EEG) index of the participants verified the effect of the limb exercise project, which was aimed at PS elevation, on improving MCI patients' cognitive function. Scientific evidence regarding early MCI intervention on a large scale was developed, and AD occurrence can ultimately be deferred.

1.4 Significance of the Study

Therefore, this present study employed PS elevation as a basis for designing the form, content, and intensity of the physical exercise. Elevating PS through a new mode of limb exercise can compensate for inadequacies of conventional exercise interventions and can in turn use psychological function to explain the positive effect of physical exercise on the health of older adults. The risk of MCI patients developing AD is 10 times higher than that of normal older adults, clearly indicating the priming effect of MCI on AD onset. Current prevention studies on AD have shifted from the clinical phase to the preclinical phase because MCI prevention and reduction in older adults (aged ≥ 65 years) are particularly crucial. Early MCI diagnosis and interference are critical to AD prevention. If older adults receive treatment during early-stage MCI, the occurrence of AD can be deferred to its fullest, ensuring the quality of life of older adults with advancing age. Therefore, we used PS elevation as the basis for designing the form, content, and intensity of the physical exercise, investigated the importance of limb exercise (aimed at PS elevation) on MCI, and explored the effect of limb exercise for improving the cognitive function of MCI patients.

This study employed the elevation of PS as a basis, designed the form, content, and intensity of the physical exercise, and aimed at determining the significance of limb exercise, which was aimed at elevating PS, on MCI. The theoretical significance of this study is as follows:

a. Through a baseline survey, the PS and cognitive function of the recruited participants were evaluated, the connection between PS and the cognitive level of MCI patients was verified, and the diagnostic value of PS used in MCI screening was confirmed.

b. To the PS and current cognitive level of the participants, three dimensions, namely the form, content, and intensity of physical exercise, were employed to construct a set of limb exercises for improving the cognitive function of MCI patients.

Significance of this study is as follows:

a. Through the development of a limb exercise aimed at PS elevation, the physical and cognitive functions of MCI patients can be maintained and improved; thus, the quality of life of MCI patients with advancing age can be elevated.

b. This study constructed a set of standardized limb exercise items based on elevating PS and is thus beneficial for clinicians promoting MCI intervention strategies applicable to older adults living in urban communities and nursing homes.

1.5 Research Questions and Hypotheses

A quasi-experimental study was used for investigating and verifying the study aim, undertaking the following specific research questions:

a. Whether the psychomotor speed of MCI patients is correlated to their cognition level, and whether it can be regarded as an indicator during screening.

Hypothesis: After a baseline investigation, a significantly positive correlation is observed between the psychomotor speed and cognition level of the research subjects.

b. How can a limb exercise plan that improves the cognitive function of MCI patients be developed on the basis of the psychomotor speed and cognition level of MCI patients?

Hypothesis: Following intervention, the psychomotor speed, cognition level, and EEG image features of the experimental group differ significantly from those in the control group, and improvement in the cognitive function of the experimental group is higher than that in the control group.

c. Can the limb exercise project aimed at PS elevation generate a positive effect on the level of improvement in cognitive function of MCI patients (i.e., PS, cognitive level, and EEG)?

Hypothesis: After the intervention, a statistical difference was exhibited between the participants of the experimental group and those of the control group regarding PS, cognitive level, and EEG. A higher level of improvement was demonstrated by the participants of the experimental group.

1.6 Definitions

For the purposes of this study, the following definitions were utilized.

1.6.1 Alzheimer's disease (AD)

AD is a chronic illness that is characterized by clinical cognitive impairment and a relatively slow progression (4–20 years) that ultimately results in death (Alzheimer’s Association, 2014). AD is characterized by a slow decline in memory, cognition, language, personality, and mobility. Additionally, resulting significant impairments are also linked to feelings of depression and disconnection from society (Williams & Tappen, 2008; Yu & Kolanowski, 2008).

1.6.2 Mild cognitive impairment (MCI)

MCI is a heterogeneous state between normal aging and early dementia. It is characterized by cognitive decline that is greater than expected for an Individual’s age and education level, in a person with essentially normal functional activities (i.e., instrumental activities of daily living), who does not have dementia (Petersen，2004). The diagnosis of MCI was made if the patient met the following criteria: (1) memory complaint; (2) normal activities of daily living; (3) normal general cognitive function; (4) abnormal memory for age and (5) not demented (Petersen et al., 1995).

1.6.3 Psychomotor speed (PS)

The “psycho” of psychomotor refers to the brain’s thinking ability and “motor” refers to physical movement. Psychomotor is a term emphasizing psychological progression and broadly incorporates the flow of thinking and the volitional movement generated from muscle-controlled activities. PS can be observed and measured from four aspects (Sobin & Sackeim, 1997): gross motor activity, body movement, speech, and motor response time. PS is an objective and quantitative measurement indicator, and neuropsychological testing methods such as the finger-tapping test (Schmitt, 2013) and Purdue Pegboard test (Buddenberg & Davis, 2000) are commonly conducted for evaluating it. These two testing methods were employed in this study to measure PS. PS slowness is exhibited in various forms, and the external signs of PS performance mainly involve the following: slowness in basic movements (e.g., whole body activity, facial activity, and activity requiring delicacy performed by other body parts), slowness and incoherence in language, and decline in calculation ability. People with severe PS slowness may experience a decline in performing daily activities and may be incapable of making decisions promptly when encountering unexpected incidents (MBF, 2008).

1.6.4 Structured Limbs exercise

Limb exercise is a type of physical exercise. We provided the operational definition of limb exercise according to the time, content, and intensity involved in the exercise. The limb exercise was performed 3 cycles per week for the 10 weeks of the intervention period. The limb exercise incorporated a warm-up exercise with upper limb exercises (comprising a board-nailing game, throwing sandbags at a target, and ball games for the upper limbs), lower limb exercises (including hopscotch, the pointing of toes towards the ground, and a support exercise using the heel), and a relaxation activity. The warm-up exercise, limb exercises, and relaxation activity were conducted for 10, 40, and 10 minutes, respectively.

1.6.5 Electroencephalogram (EEG)

EEG is a fundamental physiological signal which can be collected easily with a tiny wearable and portable monitor. The electrical signals from the brain which on display on a chart recorder provide recordings known as electroencephalograms. Since the collection device is portable and has a small footprint on the body, it allows the capture of EEG signals from individuals in various situations in a noninvasive manner. EEG is a popular example of a physiological signal that researchers used extensively in understanding cognitive functioning (Lal et al, 2002; Mamashli et al., 2010). The use of EEG for detecting and identifying attention/focus in individuals is an established concept. Several concepts have been developed for improving concentration and other cognitive functions of both attention-related disorder and head trauma patients (Clarke et al, 1998; Tinius & Tinius, 2000). The portability of such a data collection unit allows a more realistic study of human cognitive activities during task execution under various circumstances.

1.7 Assumptions

This study has following assumptions:

First, all of the recruited subjects were assumed to be capable of attempting the limb exercise, which was aimed at PS elevation, developed by this study during the study period.

Second, the period of the physical exercise was assumed to be uniformly arranged and managed by the study researchers. The researchers were assumed to be capable of conducting the limb exercise training in strict adherence with the intervention project established by the study (specific project details are discussed in Chapter 3).

Third, the test data (including PS, cognitive function measurement, and EEG) were hypothesized to be objective and accurate.

Fourth, to ensure that the test could be completed as expected, the research assistants were required to receive collective training, possess similar professional qualifications, and be capable of implementing the intervention according to the unified standard established for data collection.

Finally, the recruited subjects were assumed to be capable of performing the limb exercise for 60 minutes per day during the experimental period and of abstaining from other types of physical exercise during the same period.

1.8 Delimitations and Limitations

Delimitations

a. Preintervention

(1) The limb exercise project could be guided only by experts specializing in exercise, psychology, and psychiatry and required revising between its pretest and implementation.

(2) Because of the constraints of certain objective factors such as the study period, funding, and site, this study was conducted at only two senior activity centers in urban communities of one city (15 residential areas) and one nursing home. The intervention was thus conducted through the arrangements and under the supervision of relevant personnel, and the activity was performed under the auspices of the senior activity centers and nursing home.

(3) The subjects were recruited according to the standards set for including and excluding subjects. The research assistants also received scientific and collective training.

(4) No other activities were performed except for the ones conducted by this study at the senior activity centers and nursing home, and the intervention activity was implemented based on the voluntary consent of the subjects engaged and on the principle that the intervention was safe and healthy.

(5) A favorable relationship was developed with the subjects and their family members; in addition, to elevate the enthusiasm and compliance of the subjects engaged in the study, the subjects and their family members were informed that the training method was safe and easy.

(6) After the subjects were divided into groups, they were informed that they had been placed into either the intervention group or the control group and were asked to refrain from sharing with the subjects of the other group. A commitment was made to the subjects that the intervention method would be taught to any subjects interested in the method after the experiment was completed.

(7) The researchers guided and trained the related personnel and subjects throughout the limb exercise process.

(8) Before the intervention, the subjects signed an informed consent form and autonomously decided whether to participate in the study; in addition, the subjects had the right to end their participation at any time with no punishment or discrimination from the personnel at the senior activity center. The nursing home owned the right to interpret the intervention activity.

(9) For confidentiality, the senior activity centers and nursing home involved in this study were identified using letters and the subjects were identified using numbers.

b. During the Intervention

(1) When the collective training was completed, the subjects in the intervention group were guaranteed that all of them would be able to acquire the correct intervention content and method.

(2) The conditions of each intervention period were recorded for making timely

adjustments to subsequent interventions.

(3) The supervisory role of the research assistant was exerted fully to increase a sense of responsibility among the subjects and encourage the subjects' family members to supervise them.

(4) Responsible management was implemented, and each research assistant was in charge of a specific group of study subjects.

(5) The researchers were engaged in collective training, supervising the whole course of exercises and examining the training diary; in addition, the researchers also supervised the subjects' practice conditions, particularly supervising those with unfavorable performance and offering timely encouragement for them to participate with passion.

(6) Two methods were employed in information collection and data management to ensure the accuracy of the study data: (a) A one-to-one data collection method; (b) A dual input form for data entry.

Limitations

a. The limitation of this study was that it relied on whether the older adults were willing to participate in the activity. To ensure that the study could be conducted, we contacted two urban communities (comprising 15 residential areas) to ensure that a certain number of study subjects could be recruited. Therefore, the generalizability of the study results is limited by the locations and number of participants involved.

b. The study subjects may have come from the same residential area and thus problems associated with test pollution and information exchange were inevitable. However, before the intervention, the subjects were informed about the purpose of this study and that the control–wait method was to be adopted for the control group (i.e., the limb exercise training was temporarily not performed). The older adults in the control group were informed that, if they were interested in this method, the exercise data would be released and the training could be offered to them after the experiment was completed.

c. This study lasted only 6 months. To examine the long-term effects of the intervention, future studies can prolong the intervention period or conduct follow-up investigations.

CHAPTER 2

REVIEW OF THE LITERATURE

AD is the most common type of dementia and is a neurodegenerative disease that causes multiple cognitive impairments such as losses of memory, execution ability, sense of direction, visual–spatial ability, and language and thinking ability. The occurrence and development of cognitive impairment in older adults is a long process and may occur for years or decades before the preclinical stage. Although treatment can still delay the process of cognitive decline during the final progression of the disease, the existing impairment is irreversible, particularly when treatment occurs after dementia has developed. MCI is a transitional state between the normal ageing process of the brain and early dementia. A person in this state has memory impairment that exceeds the assessed condition of similarly aged people, although no effects appear in the person’s daily life and activities and the state of memory impairment has not yet satisfied the diagnostic criteria for AD. Older adults typically experience some extent of declining cognitive function with increased age, particularly a decline in memory function. Only one of 100 people demonstrates no decline or a nonresident decline in cognitive function (Petersen, 2011). The prevalence of MCI patients developing dementia is 10%–15%, with some MCI patients remaining stable for a certain period. If MCI patients do not receive treatment in a timely manner, 50% of them will turn into AD patients in 5 years (Gauthier et al., 2006). The prevalence of normal older adults developing dementia is only 1%–2% (Li et al., 2012). The risk of MCI patients developing AD is 10 times higher than that of normal older adults, clearly indicating the priming effect of MCI on AD onset. MCI patients exhibit a high risk of developing dementia. Current prevention studies on AD have shifted from the clinical phase to focus on the preclinical phase because MCI prevention and reduction in older adults (aged ≥ 65 years) are particularly critical. Early MCI diagnosis and interference are critical to AD prevention. On the basis of the concept, prevalence, clinical manifestation, supplementary examination, risk factor, and intervention of MCI, we summarized studies on MCI and its development.

2.1 Diagnosis and Classification of Minor Cognitive Impairment

A report released by the Quality Standards Subcommittee of the American Academy of Neurology officially recognized the following MCI standard proposed by Petersen et al. in the 1990s: (1) A person experiences an impairment in the subjective report of memory, as proven by other people familiar with the person; (2) An objective evidence of memory impairment (a memory test score that is 1.5 points lower than the normal standard deviation of other people of the same age and cultural level); (3) A minor abnormality on the overall cognition rating scale, such as a Level 2 or 3 abnormality on the global deterioration scale or a clinical dementia rating ≤ 0.5; (4) Normal general cognitive function; (5) Normally maintained activities in daily life; (6) No standard criterion for dementia is satisfied, and any physical and psychological diseases that may result in brain dysfunction are excluded (Petersen et al., 1999). Petersen divided MCI into amnestic MCI (aMCI) and no amnestic MCI (naMCI), depending on whether memory function is involved in the impairment. These two types of MCI are further classified into single domain and multiple domains, depending on whether the impairment is limited to one or multiple cognitive domains. With the course of disease development, aMCI with single- or multiple-domain impairment may turn into AD; naMCI with single-domain impairment primarily becomes frontotemporal dementia, whereas naMCI with multiple-domain impairment typically becomes dementia with Lewy bodies (Petersen, 2009; Petersen, 2011). The standard proposed by Petersen for identifying MCI is widely recognized and is the most frequently used standard; however, personnel from various research domains may interpret the standard differently for specific applications because of their respective foci. Specifically, for aMCI screening in the basic research domain, studies have primarily depended on a standardized neuropsychological test to observe whether a person has memory impairment with a standard deviation lower than the set norm of 1.5 (Guo et al, 2010). By comparing an individual patient's score with the general population norm, this diagnostic criterion based on a standardized neuropsychological test has neglected the fact that considerable individual difference exists among older adults. In the clinical practice field, clinicians emphasize observations of whether patients exhibit cognitive decline, value self-described cognitive decline and that reported by their family members, and focus on the clinical experience of individual physicians (Lu et al, 2011). Such cognitive decline is typically gathered from the subjective reports of the patients themselves and those who are familiar with the patients; in addition, the physicians' clinical experience is also incorporated for assessing cognitive decline in patients. Consequently, the assessment of cognitive decline loses its objectiveness to some extent.

2.2 Epidemiology of MCI

Considerable difference exists in the global prevalence of MCI because of the heterogeneity of diagnostic methods and differences in country and region, age of the population, and educational attainment. Research data obtained since 2010 indicate that MCI prevalence in different countries and among different populations is between 16.0% and 39.1% (Petersen, 2010; Sachdey, 2012). A recent met-analysis of MCI indicated that the MCI prevalence of older adults in China is 12.7% (95% confidence interval = 9.7%–16.5%) and that MCI prevalence in the western region (14.7%) is higher than that in the eastern region (9.6%) (Nie, Xu, & Liu). MCI prevalence increases with age (Tervo et al, 2004). A met-analysis (Nie et al., 2011) determined that the MCI prevalence in China of older adults aged 60, 65, 70, 75, and 80 years was 12.7%, 17.1%, 23.8%, 32.4%, and 43.7%, respectively. Although the data provided by an epidemiological survey differed, it is irrefutable that numerous older adults have MCI. Consequently, the increasing ageing population has heightened the focus of studies on MCI (Petersen et al., 2009).

2.3 Clinical Manifestation and Supplementary Examination of MCI

2.3.1 Cognitive Function Impairment and Psychological Behavior Abnormality Are Primarily Exhibited in MCI

Studies have indicated that MCI patients demonstrate some extent of decline in a number of cognitive functions, such as memory, execution ability, sense of direction, visual–spatial ability, and language and thinking abilities; among them, memory function impairment is the most common (Collie, 2000; Vogel et al., 2004). The execution function is a crucial part of advanced cognitive processing and aims at fulfilling a particular goal by flexibly integrating different cognitive processing processes and cooperating with operational functions. Studies have indicated that the test scores of MCI patients for auditory-verbal memory were lower than those of the normal participants in the control group and that the difference exhibited in execution ability examinations had statistical significance (Guo et al, 2009). MCI patients demonstrate defects in the following abilities: semantic memory, episodic memory, word-listening memory, picture mapping, and picture arrangement (Dudas et al, 2005). MCI patients are not only associated with impairment in cognitive function and decline in execution function but are also accompanied by abnormalities in psychological behavior. Epidemiological survey data based on urban communities in the United States indicated that 43.1% of MCI patients have symptoms of abnormal psychological behavior, with 28.7% of them satisfying the clinical diagnostic criteria. The primary symptoms were problems associated with depression, irritability, apathy, sleep disorders, and agitation/aggression (Lyketsos et al., 2002; Lopez et al., 2005). In addition, some studies have indicated that MCI patients with neuropsychiatric problems have greater potential of developing cognitive impairment than those with no evidence of psychological behavior disorders (Feldman et al., 2004).

2.3.2 Supplementary Examination of MCI

Neuropsychiatric Scale Measurement

Mini-Mental Status Examination (MMSE), a short test of mental status, and the Montreal Cognitive Assessment are the scales commonly employed for MCI screening. Designed by Folstein, Folstein, and McHugh (Folstein et al, 1975), the MMSE is a scale for screening dementia; yet, it has no specificity and a relatively low sensitivity as a tool for MCI screening. The MMSE is used primarily to detect people whose cognitive function is generally normal but who have a risk of developing MCI or AD in the future (Tang et al, 2009). Within the normal range of the MMSE, the Montreal Cognitive Assessment can be employed to detect MCI (Nasreddine et al, 2005). A joint usage of the screening tools can substantially increase the sensitivity and specificity when testing for MCI. Software versions of the MCI screening tools were developed and can increase screening efficiency; however, a certain level of computer competence is required of the recruited subjects.

Measurement of Clinical and Biochemical Indicators

Thus far, a biological indicator with sensitivity and specificity is lacking. Tang and Kumar (2008) reported that MCI patients have increased cerebrospinal fluid (CSF) tau proteins and a reduced CSF Amyloid-β (Aβ) 42 level. Leow (2009) conducted follow-ups on the tau and Aβ levels of 327 patients with MCI, with the results being similar to those of patients with dementia. In the diagnosis of early-stage AD, an increase of tau protein phosphorylation and Aβ exhibited specificity. An increase of CSF tau proteins is considered as one predictive biological indicator of MCI converting to dementia. Aβ neurotoxicity and tau protein phosphorylation are two critical pathological changes occurring AD development. Although the aforementioned biomarkers can reflect and classify the type of cognitive impairment, acquiring the biomarkers, particularly the CSF sample, is a difficult process. Therefore, clinical application of the biomarker is limited to some extent.

Gene Mapping in Genetics

Caselli (2007) reported that MCI patients with genotype apolipoprotein E (apoE) 4 have the risk of developing AD. Petersen et al. (1995) considered increased age to increase the risk for MCI patients with genotype apoE4 of developing AD; thus, the genotype apoE4 can be regarded a predicting gene. A randomized, double-blind, controlled trial conducted by Weiner (2009) determined that 63% of 1,077 patients with MCI from a community were apoE-ε4 and cholinesterase-positive carriers. Jung (2008) examined the CSF of 60 patients with cognitive function impairment and found that the MCI and dementia groups exhibited reduced haptoglobin precursor allele 1 and serum retinol binding protein. Genetics remains a frontier research method, but haptoglobin precursor allele 1 and serum retinol binding protein can be employed as early biological indicators for MCI prediction.

Event-Related Potential

The Chinese scholar Wang employed event-related potential (ERP) in examining cognitive function and determined that the P50 amplitude increased and that the P300 latency was clearly prolonged in MCI patients, thus indicating that P300 has a certain value for clinical diagnoses of MCI and early AD (Wang et al, 2010). However, because changes in ERP may result from various factors, those leading to the decline in cognitive function observed in AD and MCI cannot be distinguished from other factors. Therefore, ERP exhibits an unfavorable specificity.

Neuroimaging

Positron emission tomography (PET) and single photon emission computed tomography (SPECT) can be adopted for monitoring blood flow and glucose metabolism. Because blood flow and glucose metabolism are two high-risk factors leading to decline in cognitive function, SPECT and PET are effective tools for diagnosing MCI and early AD. Because of its high spatial resolution, magnetic resonance imaging (MRI) has an advantage in measuring brain structure and is thus widely employed in studies on MCI. Bao (2010) regarded the entorhinal cortex and hippocampus measured by MRI to have a certain value in distinguishing MCI from normal cognition. Magnetic resonance spectroscopy can noninvasively examine chemical compositions in vivo. A reduction in the N-acetyl aspartate/myo-inositol ratio can distinguish MCI from a normally ageing brain (Metastasio et al, 2006). Diffusion tensor imaging can be employed to observe brain tissue density and nerve fibers, as well as confirming relationships between various functional areas.

2.3.3 Influential Factors of the Occurrence of MCI

Demographic Distribution of MCI (Sociological Factors)

Numerous studies have verified the effect of demographic factors (e.g., age, educational attainment, and sex) on cognitive function (Tevro et al, 2004; Hänninen et al, 2002; Lopez et al, 2003). An increase in age increases MCI prevalence, and an increase in educational attainment reduces MCI prevalence. Many studies have debated the relationship between the factor of sex and MCI. Some studies have considered no evident difference in sex to be exhibited in MCI development and no evident effect of sex to be shown in the MCI prevalence of older adults (Tevro, 2004). However, Gnaugll et al. (2004) reported that men are more likely to be associated with MCI, with an odds ratio of 1.90 (1.30–2.80).

Etiological Features of MCI (Biological Factors)

Disease progression is determined by the cause of the disease and its related pathological changes in specific regions of the brain. Markesbery (2010) reviewed nine prospective studies and conducted follow-up research on MCI patients for 3–4 years, revealing relevant evidence associated with the course of the disease and its aetiology. Patients with aMCI are more likely to develop AD; specifically, compared with normal older adults, aMCI patients typically have neurofibrillary tangles in the hippocampus and entorhinal cortex, as well as having medial temporal-lobe atrophy. In addition, naMCI patients and aMCI patients with Parkinson’s disease have a higher tendency to develop Lewy body dementia, pathological changes in the argyrophil granules, and neuropathy of the Lewy body. Finally, aMCI and naMCI patients with mild stroke and a reduced cerebral blood supply are likely to develop vascular dementia.

Risk and Protective Factors of MCI Occurrence

Of the previously conducted studies, only four studies with systematic evaluations have reported risk factors and protective factors specifically related to MCI occurrence. In addition, a maximum of 15 studies have performed systematic evaluations of these four studies (Beaulieu-Bonneau & Hudon, 2009; Luck et al., 2010; Monastero et al., 2009; Sofi et al., 2010). The noncorrective risk factors included advanced age, APOE-ε4, low educational attainment, and ethnicity (e.g., African Americans, Hispanics); the corrective risk factors included hypertension, a previous history of heart disease, depression, and sleep disorders. A well-publicized protective factor is following a Mediterranean diet (a diet centered on consuming fish, vegetables, and red wine). Evidence of other risk or protective factors related to MCI occurrence lack systematic evaluation either because the factors are under preliminary study, remain debatable, or entail prospective studies based on individuals (Geda et al., 2010; Petersen et al., 2010). The risk factors under preliminary study involve cardiovascular accidents (e.g., diabetes and metabolic syndrome), alcohol intake, and male sex; the protective factors under preliminary study include physical exercise, cognitive activity training, and social participation.

MCI Conversion Risk Factors

Studies have shown that hypertension, hyperlipidemia, and diabetes are risk factors for MCI converting into AD and for accelerating the progression of MCI into dementia. Some studies have even indicated that diabetes can serve as a predictor for MCI converting into dementia (Li et al., 2012). Debette et al. (2011) reported similar results and indicated that hypertension and diabetes occurring in middle age can accelerate the extent of cerebral vascular impairment and hippocampal atrophy, precipitating a decline in execution function 10 years later. However, some studies have offered the contrasting viewpoint (Abner et al., 2012) that baseline blood-pressure levels can reduce the risk of MCI converting into dementia. In addition, studies (Gao et al., 2012) have shown that general conditions (i.e., sex, age, educational attainment, and marriage status) and lifestyle (e.g., cigarette smoking and alcohol drinking) affect MCI conversion.

Overall, the cause of MCI disease and its related factors continue to be explored (Daviglus et al., 2010), and thus study results have predominantly been based on data obtained from retrospective studies. The Cardiovascular Health Cognition Study in the United States suggested establishing an "Alzheimer's disease risk" index and classifying older adults into three classes: low, moderate, and high risk of developing dementia (Barnes et al., 2009). By accumulating evidence of factors influencing MCI development, this index can also provide a diagnostic index for MCI patients at risk of developing dementia. In addition, this index is beneficial for health care and public health service personnel in screening MCI patients at an early stage and predicting their decline in cognitive level, thus providing a timely intervention to prevent the occurrence and progression of MCI.

Actively researching MCI risk factors and searching for intervention treatments for MCI have considerable value for improving the cognitive function of older adults, elevating their quality of life, and easing the considerable pressure and burden of MCI patients on society and families.

2.3.4 Current Interventions for MCI

Currently, the MCI intervention strategy comprises nondrug intervention (physical training, and cognitive intervention) and drug intervention (Rojas-Fernandez, 2012; Teixeira et al., 2012; Lovden et al., 2011; Joosten-Weyn et al., 2010). To prevent and reduce drug side effects, most studies have recommended that MCI treatment focus primarily on nondrug intervention (Daviglus et al., 2010).

MCI Drug Interventions

Currently, many drugs are known to be capable of improving cognitive impairment; however, the U.S. Food and Drug Administration has not yet approved drugs used for treating cognitive symptoms in MCI. Drug preparations for promoting and protecting brain function have proven effective for preventing the progression of cognitive decline. Specific, representative cholinesterase-inhibiting drugs (drug preparations for promoting brain function) are donepezil, galantamine, and rivastigmine. A theory has hypothesized that a lack of selective cholinergic neurons in the basal forebrain obstructs the cholinergic input of cortical neurons, thus causing cognitive decline. A cholinesterase inhibitor can suppress the hydrolysis of cholinesterase into acetylcholine, increasing the concentration of acetylcholine in the brain and in turn enhancing cognitive activity (Salloway et al., 2004; Litvan et al., 2003; Ferris et al., 2009). The drug preparations for protecting brain function involve antioxidants and Ω-3 polyunsaturated fatty acids. The pharmacological effects of these drugs may be related to promoting the release of neurotransmitters and hormones, increasing brain–blood flow, and slowing down the progression of brain pathology (Nagaraja & Jayashree, 2001; Chiu et al., 2008). Simultaneously, studies have found substances such as B vitamins, ginseng, Ginkgo biloba leaf extract, and acetyl-L-carnitine to be capable of promoting and protecting brain function (Daffner, 2010). With flavonoids and the active mushroom ingredient extracted from Ginkgo (used in Chinese medicine) as the main ingredients, the extract of Ginkgo biloba leaves has strong free-radical-scavenging and neuroprotection effects, can suppress membrane lipid peroxidation, dilates blood vessels, and has antithrombotic effects. Clinical trials have verified that Ginkgo biloba leaf extract has a favorable effect on improving the cognitive function and social skills of AD patients; however, two recent, large-scaled, randomized, double-blind, and placebo-controlled (i.e., one study employed solely the Ginkgo biloba leaf extract and the other study combined Ginkgo biloba leaf extract with donepezil) studies on MCI prevention found that Ginkgo biloba leaf extract has only a slight effect on deferring memory decline in normal older adults (Dodge et al., 2008) and cannot prevent MCI from progressing into dementia (DeKosky et al., 2008).

Thus far, sufficient evidence is lacking for verifying the effectiveness of the aforementioned drugs for preventing MCI occurrence or progression (Daviglus et al., 2010). According to data released by the U.S. Food and Drug Administration, statins (a type of drug served as a preparation for protecting brain function) increase the risk of cognitive function impairment (Rojas-Fernandez & Cameron, 2012).

MCI Nondrug Interventions

a. Cognitive Intervention

Numerous studies have verified that MCI is associated with brain and cognitive plasticity; thus, intervening in the progression of cognitive impairment can effectively delay decline in cognitive function and prevent MCI from becoming AD (Li, 2011; Simon, 2012). Because episodic memory is the earliest clinical symptom of MCI and is the most severely impaired cognitive function, studies have frequently focused on episodic memory for producing targeted interventions, as well as simultaneously conducting studies on cognitive training involving such aspects as attention, processing speed, language, visual–spatial ability, and execution ability (Kurz et al., 2009; Rozzini et al., 2007; Wenisch et al., 2007). The specific training methods employed in memory intervention are face–name matching, cognitive map, clue method, classification method, hierarchical organization, location method, no-error learning, and visual imagery. The training method employed in each intervention study differs, and some studies have simultaneously employed multiple training methods. An analysis of the elements of MCI cognitive intervention (Li et al., 2011) and a systematic review (Simon et al., 2012) of cognitive intervention in MCI have both indicated that cognitive intervention has a promotive effect on the objective assessment and subjective report of the comprehensive cognitive ability of patients with aMCI. Specifically, cognitive intervention has an intermediate promotive effect on language and self-rated anxiety and has a relatively minor promotive effect on episodic memory, semantic memory, execution function, visual–spatial ability, attention, quality of life, and daily life. Study follow-ups showed that these improvements were maintained to some extent. Of the various training methods, individual or group goal-oriented rehabilitation was indicated to be more effective (Clare et al., 2009). In addition, using the computer as a tool for training older adults and as a supplementary memory teaching strategy can lead to a favorable intervention effect (Flak et al., 2014). Previous studies have verified that intervening in MCI development is effective; however, recent studies have focused mainly on cognitive intervention. The WHO indicates that health is a comprehensive concept comprising physical, psychological, and social adaptation; therefore, a comprehensive intervention involving these three aspects within an expected period would be more effective than an intervention involving only a single aspect.

Existing studies have seldom examined the no cognitive domains of MCI, such as popularizing prevention knowledge, increasing dementia risk awareness, acupressure, cognitive training, and relaxation training. On the basis of Chinese traditional medicine, studies in China have examined MCI intervention by adopting traditional Chinese medicine and acupuncture and have obtained favorable results (Liu et al, 2011; Fang et al, 2011). Simultaneously, studies have indicated that MCI prevalence is related to the physical exercise performed in daily life. This present study primarily explored the effect of physical exercise on cognitive function; consequently, the following section centers on summarizing the effect of physical exercise on MCI.

b. Physical Exercise

Physical exercise plays a crucial role in promoting physical health (Kotecki, 2014). Numerous studies have verified that physical exercise has a protective effect on cognitive function during later life (Anderson et al., 2010; Ang et al., 2010; Kim et al., 2011). Animal studies have also provided positive evidence regarding this topic (Garcia et al., 2011). Varying exercise form, intensity, and frequency can produce different effects on the cognitive function of older adults. Lam (2012) verified the effect of Tai Chi and stretching exercise on cognitive function and found that, 1 year after the experiment, the extent of decline in cognitive function in the Tai Chi group was minor in relation to the stretching group, thus indicating that regular exercise, particularly physical and mental training combined with cognitive load and coordination-ability training, has a protective effect on the cognitive function of older adults. Davey (1973) employed theory regarding the short-term interaction of exercise and cognitive function and verified that moderate-intensity exercise can improve cognitive function more than mild- or strong-intensity exercise and can improve the speed of information processing, memory, and attention. The theory of exercise–cognitive interaction with a delayed stimulation states that a reasonable and specific distribution of cognitive load during exercise training enables the cognitive function to achieve a more favorable state than an exercise–cognitive interaction with low-level motor stimulation; in addition, an overly high level of motor stimulation cannot maintain improvements in cognitive function because of disturbed neuron stability (Dietrich, 2011). Knab (2012) considered that, when the factors of demography and lifestyle are set, the frequency of doing aerobic exercise is clearly associated with mental state, quality of life, and perceived pressure from other adults. Consequently, no unified law is exerted in the effect of exercise form, intensity, and frequency on the cognitive function of older people. In 2007, the American College of Sports Medicine and American Heart Association first released an exercise guide for improving and maintaining the physical health of older adults. Generally, 30 minutes of moderate-intensity aerobic exercise performed 5 times per week is beneficial for physical health. In addition, strength and flexibility training should also be performed for a minimum of 10 minutes per session and more than two times per week.

Regarding the substantial effects of exercise on the cognitive process, the most evident effect is exerted on the execution and control processes, which involve project and schedule planning, working memory, suppression, and the management of multiple tasks (Colcombe et al., 2004). Relevant neurophysiological studies on the effect of physical exercise on the protective mechanism of cognitive function have indicated that, from the perspective of cognitive neuroscience, exercise can increase the release of neurotransmitters (Perry, 2013; Lin et al., 2013), slightly adjusting neuron structure and secreting growth factor in various brain tissues (Huang et al., 2014). In particular, when performing aerobic exercise requiring strength and flexibility, activity in the prefrontal lobe, parietal lobe, and temporal lobe of the brain instantly increases, enabling exercisers to elevate their attention control and execution abilities continually (Kramer et al., 2006). Moderate-intensity exercise of large muscle groups can elevate oxygen intake, delivery, and utilization of exercisers, as well as stimulating the pituitary gland to secrete β-Endorphin, a favorable type of physiological sedative; thus, the ability of the central nervous system to react can be elevated, and the body's tolerance of external stimuli can be strengthened (Mehl et al., 1999). During exercise, the nervous system generates micro-electrical stimulation, which can ease muscle tension and depression, relax the brain cortex, mitigate physical pain and psychological stress, and elevate PS (Hartmann et al., 2005). Exercise exerts a neuroprotective effect for neurodegenerative diseases (Gregory et al., 2012). Simultaneously, exercise can serve as an efficient, economic, and easily available intervention strategy that has few side effects and can substantially reduce the rate of cognitive decline in patients with vascular cognitive impairment (Teresa et al., 2010; refer to the original text).

Relatively few studies have examined the effect of physical exercise on the cognitive function of MCI patients. Two studies that are frequently quoted by studies have summarized five types of clinical trial studies on exercise and cognitive function in MCI patients (Lautenschlager et al, 2010; Teixeira et al., 2011). These studies have indicated that moderate-intensity exercise (e.g., walking) can elevate cognitive function related to the execution ability, memory, and attention of MCI patients, particularly for female MCI patients. Simultaneously, high exercise participation and compliance enable more evident cognitive function improvement in MCI patients. Exercise training can improve the physical function of older adults, and standardized exercise training is useful for clinicians who promote the MCI intervention strategy and apply it to members of communities (Elsawy et al., 2010).

Currently, MCI is a popular topic for studies on an ageing population and on the early diagnosis and prevention of AD. However, the following problems must be urgently addressed. First, a unified concept and corresponding diagnostic criteria are needed; specifically, the broad concept for diagnostic criteria and the lack of unified diagnostic exclusion criteria have resulted in low diagnostic consistency (i.e., the Kappa index) among doctors. Second, a huge difference exists in assessment tools employed for MCI diagnosis. Because of regional and cultural differences, the direct application of international assessment tools to studies in China clearly offsets the reliability and validity of examinations. The various diagnostic criteria have different assessments regarding severity of cognitive impairment, leading to the lack of a comprehensive neuropsychological assessment. Finally, numerous studies have verified that MCI is associated with brain and cognitive plasticity; thus, intervening in the progression of cognitive impairment can effectively postpone decline in cognitive function and prevent MCI from becoming AD (Li, 2011; Simon, 2012). Currently, the MCI intervention strategy comprises nondrug intervention (physical training, cognitive intervention, and psychological intervention) and drug intervention. Of the studies examining the effect of exercise training on cognitive function, studies have investigated the relationship between exercise training and the cognitive function of older adults, have traced the results of exercise training on cognitive improvement in older adults, and have meticulously explored the effect of varying exercise intensity, frequency, and duration and changing training methods on cognitive function in older adults. However, the studies mostly involved the effect of intervention on normal older adults, with no studies having focused particularly on older adults with MCI in urban communities. In addition, the exercise training methods employed in these studies were singular, and the conventional content design of the exercise training frequently neglected PS, which is a sensitive indicator for assessing cognitive function.

MCI is a cognitive impairment process caused by multiple factors and is associated with several levels and ranges. The condition of each MCI patient exhibits specific characteristics, and thus the intervention should stress specificity, strengthen and promote health education, and emphasize cognitive rehabilitation training to slow the brain's ageing process, elevate individual quality of life, and add considerable value to national quality of life.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

The purpose of this chapter is to present the subjects, instrumentation, and methodology used in this study. The chapter is divided into the following sections: research questions, experimental design, subjects, apparatus and instrumentation, research procedures and statistical methods. The research questions are presented to introduce the experimental design, which outlines the configuration of the study. The participant section describes the district, communities, and older adults who participated. The apparatus and instrumentation section provides an overview of the exercises program. The next section, entitled research procedures, reviews the protocol and methods used to collect the data. The sixth section explains the statistical methods used to analyze the data.

3.1 The purpose of the study

This study focused on designing the forms, contents and intensity of limb exercises that facilitated raising psychomotor speed. The objective of this study was to investigate the crucial meanings of limb exercises designed to raise psychomotor speed for maintaining cognitive functions of patients with mild cognitive impairment (MCI), and to expose the effects limb exercises exerted on improving cognitive functions of MCI patients.

Research Questions and Hypotheses

The research questions were divided into 3 aspects:

c. Whether the psychomotor speed of MCI patients is correlated to their cognition level, and whether it can be regarded as an indicator during screening.

Hypothesis: After a baseline investigation, a significantly positive correlation is observed between the psychomotor speed and cognition level of the research subjects.

d. How can a limb exercise plan that improves the cognitive function of MCI patients be developed on the basis of the psychomotor speed and cognition level of MCI patients?

Hypothesis: Following intervention, the psychomotor speed, cognition level, and EEG image features of the experimental group differ significantly from those in the control group, and improvement in the cognitive function of the experimental group is higher than that in the control group.

e. Can the limb exercise project aimed at PS elevation generate a positive effect on the level of improvement in cognitive function of MCI patients (i.e., PS, cognitive level, and EEG)?

Hypothesis: After the intervention, a statistical difference was exhibited between the participants of the experimental group and those of the control group regarding PS, cognitive level, and EEG. A higher level of improvement was demonstrated by the participants of the experimental group.

The following sections in this chapter describe the methods undertaken to investigate or verify these questions.

3.2 Experimental Designs

This study adopted a quasi-experimental design. However, there was a random assignment of group to treatment. This study did have a control group and an experimental group, which made it a quasi-experiment. Quasi- experimental design "embodies the characteristics of experimental research except for the random assignment" (Mertler & Charles, 2005). Within this quasi-experimental design, this study employed grouped comparison design with assessments at baseline, mid-point, and trial completion (Table 1). Subjects were placed into the experimental or control group based on random numbers. Details of the trial have been reported elsewhere.

Table 1

Experimental Design

Group	BASELINE	MID-POINT (weeks 1-5)	TRIAL COMPLETION (weeks 6-10)
Experimental Group	Regular activities	Intervention *	Intervention *
Control Group	Regular activities	Regular activities Health education handbook Health education lecture	Regular activities Health education handbook Health education lecture

* ***Intervention**: regular activities; health education handbook; health education lecture; 60-minutes of Structured Limbs exercise*

3.3 Participant

Population:

The older adult patients with MCI living in city of Daqing.

Sample:

The research subjects were elderly adult patients with MCI living in Communities A and B (6 residential quarters in total) and a Nursing home C.

Sampling method:

Through a convenience sampling method, this study recruited elderly adults living in Daqing, Hei Longjiang, China, Community A, Community B (6 residential quarters in total), and Nursing home C from February 2015 to June 2015. Elderly adults with MCI were screened in February and March. All subjects signed a form of informed consent before participating in this study. After a sufficient number of subjects were recruited, experimental studies were conducted from April to June.

Recruitment Criteria:

a. Inclusion Criteria

(1) The inclusion criteria were based broadly on the diagnosis criteria of MCI:

(2) Chief complaint of memory impairment by the patient, caretaker, or informants.

(3) Aged 60–70 years.

(4) Educational attainment of elementary school or higher.

(5) Score 24–26 on the scale of Mini Mental State Examination (MMSE, Typically, people with an educational attainment of elementary school receive a score of >20 on the MMSE scale, and those with an educational attainment of junior high school or above receive a score of >24.

(6) Relatively normal level of self-care ability in performing activities of daily living (ADL), indicated by attaining a score of >60 on an ADL scale.

(7) No history of dementia according to the diagnosis of a psychiatrist

(8) Being informed of the research project and voluntarily consenting to participate.

b. Criteria of Exclusion

(1) Patients with vascular dementia, Parkinson disease, or any physical or mental disease causing brain dysfunction.

(2) Patients who had undergone surgery within 1 year.

(3) Patients with impaired visual and hearing functions

(4) Patients with impaired heart function who have been restricted from exercising.

(5) Patients with a terminal disease and a life expectancy of less than 6 months.

Sample Size Calculation

Before data collection, a power analysis was performed to determine the sample size. On the basis of our pilot study of experimental design, we found a large effect (Cohen'*f* = 0.502) on cognition level, measured by measurement to MoCA. With α set at 0.05 and β (power) at 0.95, the power analysis indicated that 19 participants were required for 2 groups to detect a large effect (N =38; Figure 1）. Considering expected attrition（15%）, the decision was made to oversample (N =44). There were 44 subjects from the 15 residential quarters in two urban communities. There were also an equal number in the control and experimental groups because classrooms were randomly assigned to each group (Table 2). A power analysis was conducted and determined that this sample was adequate for the proposed statistics.

Table 2

The Number of Subjects by community, Gender and Group

Community			Group		Total
			Control	Experimental	
A	Gender	Female	4	6	10
		Male	7	5	12
	Total		11	11	22
B	Gender	Female	5	7	12
		Male	6	5	11
	Total		11	11	22
Total			22	22	44

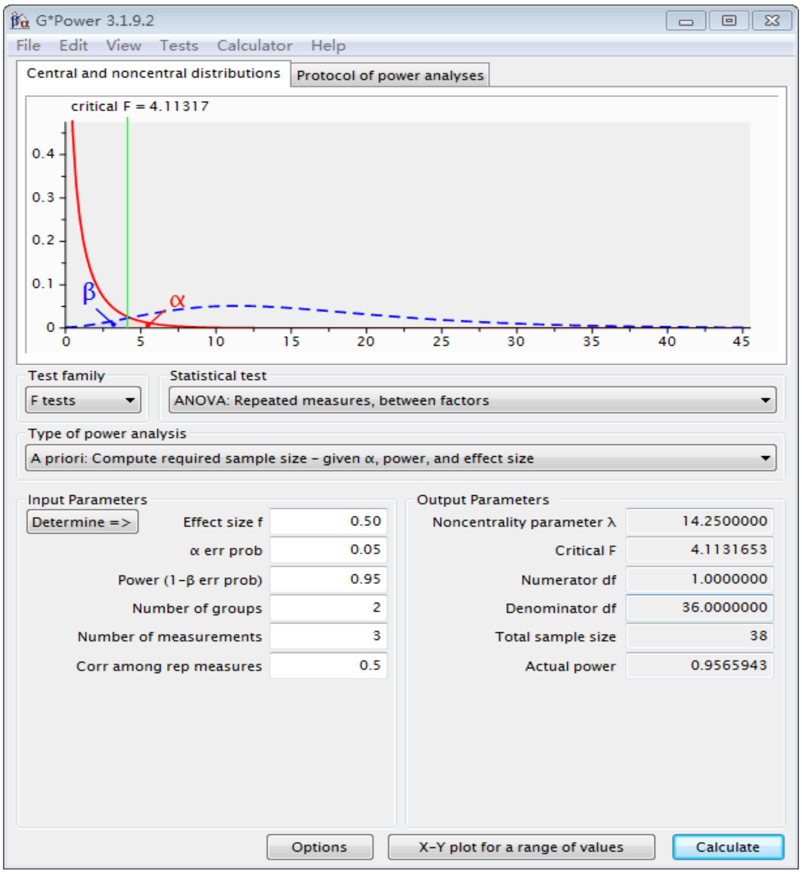


Figure 1 Sample Size Determination

Sampling Method:

After the 44 subjects were screened from older elderly adults residing in Communities A and B and Nursing home C, we divided the subjects randomly into a limb exercise training intervention group and a control group. Grouping was conducted through the following steps: 1) Number the subjects by their order of inclusion in the study; 2) choose an arbitrary line and arbitrary row from a random number table to begin reading 2-digit numbers; 3) take these numbers as random numbers, and write the random numbers below the subjects' numbers; 3) number the random numbers obtained by their value (those with the same value were numbered in their order of appearance); 4) accordingly, the subjects whose random number is ranked between 1 and 22 were assigned to the limb exercise training group, and those with numbers between 23 and 44 were assigned to the control group.

3.4 Apparatus and Instrumentation

3.4.1 Demographics

This study used a self-compiled demographic table to investigate the basic characteristics of the subjects. The table shows the subjects' number, sex, age, educational background, marital status, career (before retirement), monthly income, living conditions, illness history, family history, and medication history.

3.4.2 Screening Instruments

When recruiting the subjects, this study evaluated and screened elderly adults aged 60–70 years by using the MMSE and an ADL scale.

Mini Mental State Examination (MMSE)

The MMSE, currently one of the most influential instruments for screening cognitively impaired patients, was devised by Folstein (Folstein et al, 1975). The scale comprises 30 items: Items 1–5 test orientation to time, Items 6–10 test orientation to place, Items 11–13 check instant linguistic memory, Items 14–18 check attention and calculation, Items 19–21 examine short-term memory, Items 22–23 require respondents to name objects, Item 24 tests linguistic repetition, Item 25 tests reading comprehension, Items 26–28 examine linguistic comprehension, Item 29 checks linguistic expression, and Item 30 tests figure drawing. The highest attainable score of MMSE is 30 (higher scores indicate sounder cognitive function). The MMSE's test–retest reliability is 0.80–0.99; and the inter-rater reliability is 80%–90%. The diagnostic sensitivity for dementia is typically between 80% and 90% and the specificity is typically between 70% and 80% (Shulman et al, 2006). The MMSE was adopted to assess the cognitive impairment level in patients with dementia. The criteria for subjects to be determined as being cognitively impaired are as follows—illiterate group: MMSE ≤17; elementary education group: ≤20; high school or above group: ≤24 (Zhang, 2008).

Activities of Daily Living (ADL) Scale

Created by US psychologists Lawtont and Brody in 1969, the ADL scale was used mainly to evaluate capacity to perform ADL. The scale comprises 14 items divided into 2 subscales: physical self-maintenance scale (PSMS; 6 items) and instrumental activities of daily living scale (IADL). PSMS checks 6 self-maintaining ADLs, which are eating, going to the toilet, getting dressed, grooming, physical ambulation, and bathing. In addition, the IADL scale contains 8 items measuring the capacity to independently perform ADLs: use a telephone, go shopping, prepare food, perform common housekeeping duties, wash laundry, commute using various modes of transportation, maintain drug compliance, and handle financial responsibility. The items in the scale are detailed, concise, comprehensible, and concrete. During the evaluation, the subjects were asked about each item according to the order of the table. When a subject was unable to answer or could not answer correctly because of specific reasons, the results were evaluated according to the observations of informants such as family members or nursing personnel. When an item could not be answered or the subject had never performed such an activity (e.g., if the subject had no phone and had never placed a phone call), then the answer was marked (9). These scores of these cases were later handled according to research regulations. The assessment results were analyzed according to the total, subscale, and item scores. A total score of <16 means the subject has normal function; a score of >16 suggests that the subject has some level of functional decline (maximum score: 64). Regarding the scoring of individual items, a score of 1 indicates normal function and 2–4 indicates functional decline. Subjects who scored ≥3 in 2 or more items or ≥22 overall were regarded as having a notable level of functional disability. The ADL scale has favorable reliability and validity: the Cronbach' α was 0.84– 0.94 and the correlation coefficient between the validity indicator of ADL and a 36-item short form health survey was −0.60 (Sijmen et al., 2007).

3.4.3 Test Instruments

To verify intervention results, the following instruments were applied to measure the observation indicators at baseline, during the intervention, and post-intervention.

Measuring Psychomotor Speed

a. Finger Tapping Test (FTT)

This test is performed mainly to check the movement speed of the fingers and is designed to indicate a person's coordination and accuracy in performing movements. Nutt JG et al. proposed a widely applied classic method (Nutt et al, 2000) in which subjects alternately tap their index fingers on a button of an electronic tapping tool (Figure 2) as quickly and accurately as possible within 1 minute. The square-shaped button, which has a width of approximately 1.5 cm, is positioned 20 cm from the subjects. The numbers of taps made with each hand was calculated separately to identify the finger-tapping speed of the subjects.

b. Purdue Pegboard Test

The Purdue pegboard test (PPT) was designed in 1948 by Dr. Joseph Tiffin at Purdue University. The test has since been widely applied to testing in various fields, particularly in testing the workers involved in tasks requiring a high level of hand dexterity, such as assembly, packaging, and assembly line operations. Normative data on age, sex, and skilled lab our-related information have been collected. The testing method is described as follows: The subjects are asked to take the pegs from a plate one by one and insert them into the corresponding holes in a special pegboard within 30 seconds. The subjects are required to place the pegs individually by using their left hand, right hand, and then both hands, in that order. Five trials are included as part of the test. Eventually, the number of pegs placed in 3 examinations is calculated (Figure 3). The test indicates a person's dexterity and speed of hand movement and hand–eye coordination (Desrosiers et al, 1995).

Measuring Cognitive Level (Montreal Cognitive Assessment)

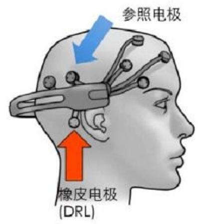
The Montreal Cognitive Assessment (MoCA) by Nasreddine et al., is a test developed on the basis of clinical experience and revised from the cognitive items and evaluation criteria of the MMSE test. The current version of the test was finalized in November 2004 (Nasreddine et al., 2005). The MoCA is a convenient instrument for quickly screening patients with mild cognitive impairment (Wang et al., 2009; Olson et al., 2008) and can be applied in conduct quantitative assessments on the cognition level of MCI patients. The present study adopted the Beijing version of the MoCA (MoCA-BJ), which was translated by Wang et al. (www. mocatest.org). The Cronbach's α of the MoCA-BJ is 0.836, which is relatively consistent with that of the original assessment (0.83) (Nasreddine et al., 2005). Thus, the MoCA-BJ has high internal consistency. The MoCA-BJ covers the following cognitive areas: visuospatial and executive capacity (5 points), naming (3 points), attention and calculation (6 points), language (3 points), abstraction (2 point), delayed recall (5 points), and orientation (6 points). The range of the total assessment score is 0–30. When the total number of years of education of the subjects is ≤12, an extra point is added to the total score to correct the bias caused by educational background. Higher scores indicate a higher level of functional cognitive capacity. Patients with scores ≥26 points are considered to have normal cognitive function. The test takes approximately 10 minutes to complete.

Electroencephalograph

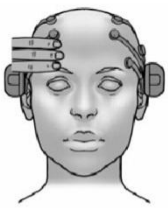
a. Collecting Electroencephalograph

To measure brainwaves, this study used a portable electroencephalograph (EEG), (Emotiv EPOC, Emotive Company) (Figure 2a). The device features 14 channel locations (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4) and satisfies the international standard use of 10–20 electrodes. In addition, the Emotiv EPOC has bipolar leads, a signal sampling rate of 128 Hz, bandwidth of 0.2–45.0 Hz, filter range of 50–60 Hz, and 16-bit resolution in analogue-to-digital conversion. Before the headset is put on, the pads of every electrode were saturated with a conducting liquid and fixed to the Emotiv EPOC neuroheadset. The device should be worn on the head in a vertical gesture of a downward motion. Once the headset is put on, the rubber electrodes CMS (left) and DRL (right) should be positioned in level with the temporal bone on each side of the head (Figure 2b). In addition, the prefrontal electrodes (AF3 and AF4) should be fixed approximately 3 finger-widths above the eyebrows (Figure 2b). Once the rubber electrodes have been affixed correctly, the reference electrodes above both ears must be pressed using both hands (Figure 2C) to ensure that the signals from the 2 electrodes are functioning (green, as shown in Figure 2d). Subsequently, every electrode must be pressed until the signals from all electrodes demonstrate proper functioning. Attached near the scalp, the Emotiv EPOC measures neurological signals and then transmits the signals to a computer. The most salient feature of Emotiv EPOC is that it can obtain brainwaves from EEG tracings. Users can become familiar with the software in a short time, enabling them to understand various brain wave patterns.

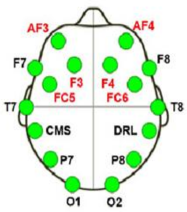
(2a) Emotiv EPOC headset



(2b) Positioning of rubber electrodes



(2c) Determining electrode positions



(2d) Electrode positions

Figure 2 Emotiv EPOC Neuroheadset and Its Wearing Method

Source: www.emotiv.com

The EEG can capture the brainwave changes in considerably high temporal resolution after a subject performs an action. Exercise training activates the functional nerves in the frontal and parietal lobe areas of the brain, and changes in the activating modes of these areas of the brain are closely related to cognitive activity (Colcombe et al., 2006; 126. Marks et al, 2007; 127. Colcombe et al., 2004).This study collected EEG data on 6 channels for the analysis (see the areas marked in red in Figure 2d): left and right prefrontal (AF3 and AF4), left and right frontal (F3 and F4), and left and right parietal (FC5 and FC 6). To understand the changes in brain activity after the subjects undertook exercise training, this study performed an EEG power spectral analysis to analyze the EEG data. Numerous previous studies related to exercise have used the power spectrum to analyze subject response to exercise training. We mainly researched the performance of power spectral values of delta, theta, alpha, beta, and gamma wave frequencies. For each frequency, we captured data from the left brain (AF3, F3, and FC5), right brain (AF4, F4, and FC6), front of the brain (frontal: AF3, AF4, F3, and F4), and the middle of the brain (parietal: FC5 and FC 6) to present the frequency characteristics.

a. Tracing conditions

Environmental requirements:

EEG tracing was conducted in a quiet, ventilated indoor space with moderate lighting, no irritation, moderate temperature and humidity, and fresh air without an unpleasant smell. The room was elegantly arranged but not overly decorated. No electromagnetic interference such as cellphones or hearing aids were allowed within a 3-m circumference of the test site. The subject and the test administer maintained at least a 2-m distance from other people, and the subject was free from any form of disturbances (e.g., people walking around, conversations, or noises).

Subject preparations:

The subjects were required to wash and dry their hair before taking the test. During the test, the subjects must be seated and remain silent and awake while keeping their eyes closed and feeling relaxed and emotionally stable. Within 3 days prior to the test, the subjects were prohibited from taking any sedative, hypnotic, or antiepileptic drug. The examination was conducted within 3 hours after a meal. The subjects were not fasted, hungry, or thirsty; they were fully rested before the test.

Neuroheadset requirements:

The wireless receiver showed a favorable signal. The EEG measuring instrument was fully charged.

Operator requirements:

The operator needed to be familiar with the properties and operating procedures of the neuroheadset. In addition, the operator was informed of the demographic data of the subject. The operator spoke gently, in case inappropriate language could provoke the subject and affect the EEG. The operator strictly adhered to all operational procedures.

b. Frequency Divisions:

Typically, human EEG frequencies range from 0.5 to 30 Hz. The range was divided into several frequency groups called frequency bands. According to the standard setting of the Emotive Xavier Test Bench 3.0.0.41, which is a software equipped with the Emovitv EPOC, the frequency bands were labeled in Greek letters as follows: delta (δ: 0.5–4.0 Hz), theta (θ: 4.0–7.0 Hz) , alpha (α: 8.0–12.0 Hz) , and beta (β: 13.0–30.0 Hz).

c. Parameter Settings of the Neuroheadset:

The neuroheadset includes 14 channels (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4), is compatible with the internationally accepted 10–20 electrode system, and adopts a bio polar lead. The signal sampling rate of the Emotiv EPOC is 128 Hz, and the bandwidth is approximately 0.2 Hz–45 Hz. The neuroheadset filters digital signals range from 50 to 60 Hz, and the resolution of the A/D converter is 16 bits.

d. Data Collection

After the instrument was connected, it was switch on and was allowed to preheat for several minutes. The neuroheadset automatically checked the signals of all of the parts. When abnormal colours (black, orange, yellow, or red) were detected, the related parts were immediately adjusted to ensure optimal signal reception. After the Emotiv neuroheadset was placed on the subject and suitable signal reception was confirmed in all of the channels, the experiment proceeded by using a sampling module to collect 1 minute of spontaneous EEG data. Subsequently, provocation tests (ie, hyperventilation tests) were performed whenever needed. A hyperventilation test was used to examine the functional state of the cerebral cortex, according to the following procedures: The subject was asked to close their eyes gently and then hyperventilate for 1 minute at a rate of 20–30 times per minute. The action was repeated 3 times (Jiang & Jie, 2004). When the hyperventilation test was completed, the data were preserved, and the Emotiv neuroheadset was removed from the subject. The neuroheadset was then cleaned and prompted to perform a self-check. Thereafter, the EEG data of the next subject were collected. When the EEG data of all of the subjects were collected, the instrument was switched off and cleaned.

e. EEG Data Analysis:

Visual analysis:

The EEG images were visually analyzed through reading (scanning and perusing) the EEG. First, basic EEG elements were observed and analyzed, including frequency, amplitude, phase, waveform, and the location, manner and rhythm of the EEG waves; EEG diagnoses were then derived from the observations, clinical symptoms, and other test results.

Power spectral analysis:

Power spectral analysis of the EEG images involves transforming the EEG images (which present the simulated variations in voltage over time) by applying fast Fourier transform, into digital spectrums that show energy (or power) and frequency. The major objective of this study was to determine the variation pattern observed during the limb-exercise intervention. EEG images were used in the analysis because they exhibit high temporal resolutions and thus can reflect the EEG changes resulting from exercise. Exercise training activates the functional nerves in the frontal and parietal lobes of the brain, and changes in the activation model of these brain areas are closely related to cognitive activities (Colcombe et al., 2006; Marks, 2007; Colcombe et al, 2004). This study involved collecting the EEG data of 6 channels (see the red highlighted part of Figure 4d), namely the left and right prefrontal lobes (AF3 and AF4), the left and right frontal lobes (F3 and F4), and the left and right parietal lobes (FC5 and FC 6). To determine the changes in the brain activities of the subjects after they participated in exercise training, this study used EEG spectral analysis to interpret the EEG data. Previous studies have shown that delta wave activities are detected in adults only when they are asleep but not when they are awake. In addition, theta wave activities are the primary EEG components in healthy children, but the theta wave activities of adults are detected only when their nervous system is suppressed. Therefore, theta wave activities serve as a testing standard for adult somnolence and depression. Alpha waves are the type of human spontaneous EEG that exhibit the most obvious rhythm and are particularly influential in the occipital and parietal-occipital lobes. Alpha wave activities are noticeably active when people are awake with their eyes are closed. However, when people open their eyes, think, or receive external stimuli, alpha wave activities are suppressed and replaced by beta waves, which are substantially distributed in the frontotemporal lobe (Hochberg et al, 2006). This study examined only the alpha and beta wave values in the power spectrum. Furthermore, we used data collected from the left hemisphere of the brain (AF3, F3, and FC5), the right hemisphere (AF4, F4, and FC6), the front of the brain (frontal lobe: AF3, AF4, F3, and F4), and the middle of the brain (parietal lobe: FC5 and FC6) to examine the characteristics of each frequency.

In previous studies, spectral analysis of EEG power has typically been used to present momentary fluctuations in EEG signals (Khushaba et al, 2012). To eliminate the effects of eye movement, blinking, and body movements, the EEG signals collected were first screened through a digital signal filter; only EEG signals between 0.5 and 40 Hz were retained. Identical component analysis was then applied to these data to reduce the effects of electro-oculography. Subsequently, this study used FFT to transform the EEG signals into waves of 4 frequencies: delta (0.5–4 Hz), theta (4–7 Hz), alpha (8–12 Hz), and beta (13–30 Hz). In the FFT process, no overlapping time windows of 0.5 seconds in length were adopted to calculate the power of the signals collected from all of the channels (AF3, F3, FC5, FC6, F4, and AF4) that were within the alpha and beta wavebands. The values measured for each time window were averaged to represent the power spectrum value of the corresponding frequency.

This study analyzed EEG data collected from two durations: the last 10 seconds before the provocation test, when the spontaneous potentials were collected in baseline measurements; and the first 60 seconds of the provocation test. The absolute value of the difference between the evoked potential values and the baseline values was divided by the absolute baseline value to standardize the measured values of each channel corresponding to each frequency band. Consequently, the effects of the individual differences in the EEG data were reduced. This study applied logarithmic (base 10) transformation to the power spectral moments of each channel corresponding to each frequency band so that the power spectral values exhibit a normal distribution. Furthermore, the EEGlab Version 11.0.0 toolbox, which was based on Matlab Version R2010a, was used for data preprocessing and analytical calculations.

3.5 Research Procedures

3.5.1 Information and Consent

Before participating in this project, the subjects signed an informed consent, which included an explanation of the project, objectives of the intervention, procedure of the intervention, information on the risks and adverse effects, potentially benefits and positive effects, statement of confidentiality, and confirmation of voluntary participation. Consent and support were received from the residential committees of Communities A and B in Daqing city and the administrators of Nursing home C. All subjects participated in the research voluntarily. Each subject confirmed that they understood the topic clearly and signed the informed consent form. The research subjects were informed of their rights; in particular, they are free to withdraw from the study at any time without incurring any cost for damages. The subjects who were found to have severe cognitive impairment in the screening were recommended to undergo further examination at a hospital.

3.5.2 Confidentiality

Subjects were assigned a unique identifier to assure confidentiality. Elderly data were stored in an electronic format as well as in written format. Electronic data were password secured on the researcher’s home and office desktop computers. Written assessment data were stored in a locked file cabinet in the researcher’s office. Within the file cabinet, each subject’s data were stored in an individual file folder labelled with his or her unique identifier rather than his or her name. The MoCA testing was maintained by community entertainment rooms as part of their routine assessment procedures. MoCA data continues to be housed in relevant community entertainment rooms. However, copies in the researcher's possession were stored in the aforementioned confidential way. These copies will be shredded after the publication of this dissertation. All data were available to the researcher only, with the exception of the MoCA data, which is available to administrators in relevant community entertainment rooms as part of regular assessment portfolio. Findings about the study were reported in general terms with no individual subjects' identities revealed. Data files used in the analysis did not contain subject names. The two participating communities were identified throughout this dissertation as community A and community B. The identity of each community is known only to the researcher so that the communities' overall data remained confidential.

3.5.3 Pilot study

Between January and February 2015, the researcher conducted a pilot study in a residential quarter in Community A. Five patients with MCI who satisfied the recruitment criteria and passed the screening for the MMSE and ADL scales were recruited. On the basis of the regular activities held in a senior activity centre, the researcher distributed health education manuals (which contained information on the current situation of MCI, factors related to pathogenesis, major clinical manifestations, and prevention measures) to these patients and implemented limb exercise intervention project among these patients. Subsequently, 5 other patients with MCI were selected to perform regular activities in the senior activity centre. The researcher also distributed health education manuals to these patients. After the intervention was completed, the researcher modified the shortcomings of the intervention process such as by simplifying the instructions for administering the scale tests, adjusting the test time, and providing individual guidance on performing the limb exercises.

After completing the intervention, the researcher collected data according to the experimental procedures, conducted relevant analysis, and confirmed significant differences between the scores of both groups. The pilot study facilitated enhancing preliminary procedures at early experimental stages as well as derived relevant assumptions and increased the success rates of subsequent experiments in the official program. After the pilot study was completed, the formal research intervention was commenced.

3.5.4 Formal Study

Implementing and Evaluating the Intervention

a. Contents and Methods of the Intervention

Control Group

(a) Participated in regular activities at a community senior activity centre (i.e., reading, chess and card games, singing, and dancing).

(b) Received an MCI health education manual, which explains the current situation of MCI, factors related to pathogenesis, major clinical manifestations, and measures to postpone or decelerate the progression of cognitive impairment.

Experimental Group

In addition to the measures of intervention implemented in the control group, the experimental group received limb exercise intervention. The detailed content and methods of the limb exercise intervention were as follows:

Content and Time Allocation of Limb Exercise Training

Warm up Exercise

Exercise time: From 9:00 AM to 9:10 AM (10 minutes)

Venue: Outdoor plaza (away from the senior activity centre to eliminate message exchange to the control group that may create bias)

Content:

Neck stretch (forward):

Slowly bend the head forward with the hands placed on the back of the head. Feel the muscles in the back of the neck being stretched out and hold the position for 30 seconds.

Neck stretch (left and right):

With the head facing forward, slowly tilt the head to the left. The left arm can be applied to the head to assist the movement, but the right shoulder must remain steady. Feel the muscles on the right side of the head stretch, hold the position for 30 seconds, and then change position to stretch the left side.

Arm stretch (deltoid):

Lift the right arm to the left shoulder, supporting the right elbow with the left arm and pulling the right arm towards the torso. Feel the muscles in the arm being stretched, and hold the position for 30 seconds before returning to the original pose and then change position to stretch the other arm.

Arm stretch (triceps):

Stretch the left arm over the head so that the palm of the left hand touches the centre of the back. Hold the left elbow with the right hand and gently pull the elbow toward the back without overexerting, noting that the body posture does not bend while pulling on the elbow. Feel the muscles in the arm being stretched, hold the position for 30 seconds, and then return to the original pose and then stretch the other arm.

Chest stretch (chest muscles):

Stretch both arms straight backwards with the hands joined (the palms facing inward). Slowly raise the arms while keeping the chest pushed out and chin tucked in. Feel the back muscles being stretched and hold the position for 30 seconds.

Chest stretch (back muscles):

Stand with legs shoulder width apart. Bend the knees slightly, holding the hands with the fingers interlocked and push the arms forward, gradually arching the back. Feel the muscles in the back being stretched and hold the position for 30 seconds.

Side stretch (oblique muscles):

Stand with legs shoulder width apart. With the eyes looking forward, extend the left arm upwards, turn the palm inwards, place the right hand on the right waist, and slowly lean to the right, paying particular attention not to bend the left elbow. Feel the oblique muscles being stretched and hold the position for 30 seconds. Subsequently, return to the original pose and change to stretch the other arm.

Leg stretch (hamstring muscles):

Stand with legs shoulder width apart with the knees bent slightly. Slowly bend forward from the pelvis and try to touch the toes with both hands (try as much as one can). Feel the hamstring muscles being stretched, hold the position for 30 seconds, and then slowly return to the original pose.

Side stretch (quadriceps):

While standing, grab the right foot with the right hand by bending the knee to face downward while maintaining balance with the left hand (hold a chair or another person’s shoulder if necessary). Avoid tilting the knee to the sides. Feel the quadriceps being stretched, holding the position for 30 seconds, and then return to the original pose and change to stretch the other leg.

Neck stretch

Neck stretch


Arm stretch


Arm stretch

(Forward) (Left and right) (Deltoid) (Triceps)

Chest stretch
(Chest muscles)

Chest stretch
(Back muscles)

Side stretch
(Side muscles)

Leg stretch
(Leg muscles)

Side stretch
(Quadriceps)

Figure 3 Warm up Exercise

Objective

Warmup exercises enabled the subjects to relax various areas of the body accordingly to their breathing rhythm, preparing them for exercise quickly. Every movement was performed slowly and steadily, enabling the subjects to experience a gentle and smooth warmup exercise. At this stage, the objective was to develop the subjects' execution capacity, physical coordination, and attentiveness.

Limb Exercise

Exercise time: From 9:10 AM to 9:50 AM (40 minutes)

Venue: Outdoor plaza

Content:

Upper Limb Exercise:

Pegboard exercise

The subjects were required to insert small metal pegs into a prepared pegboard. Subsequently, they had to remove the pegs in a specific order. The task was repeated 3 times, with each time lasting for approximately 3 minutes and totalling 10 minutes for the entire exercise.

Sandbag throwing exercise:

The subjects were asked to stand at a designated place and throw palm-sized sandbags at a 50×50 cm2 area approximately 1.5–2.0 m away from them. The subjects were required to retrieve the sandbags and throw them again for 10 times. The total exercise time was 10 minutes.

Ball-holding exercise

Basketballs or other balls of identical size were used for the seated exercise. First, the subjects were required to sit steadily on a chair with their feet parallel to their shoulders and holding a ball in front of the chest with both hands. Using the axis of the body as the centre, the subjects were asked to rotate to the left and right 10 times each (1 minute). Subsequently, they were asked to hold the ball with both hands and raise it over their head slowly, and then to return to the original pose. This exercise was repeated 10 times (1 minute). Finally, the subjects were asked to hold the ball with both hands in front of their chest and apply pressure to the ball by pressing their palms against it. The exercise was repeated 10 times (1 minute). The ball-holding exercise approximately lasted for 5 minutes.

Lower Limb Exercise:

Hopscotch exercise

Forty 30 × 30 cm squares were marked on the ground as 10 rows with each row comprising 4 squares. The squares in each row were randomly numbered from 1 to 4. The subjects were required to move in the order of the numbered squares (from 1 to 4) from Row 1 to 10. Completing this process was counted as one round. The task could repeat for several times as required. The total practice time was 10 minutes.

Foot exercise

The subjects were asked to stand while shifting the body weight alternatively between their toes and heels. The subjects were required to practice the exercise several times within 5 minutes.

Objective:

The limb exercise at this stage was aimed to developing the task execution capacity, attentiveness, fine motor skills, hand–eye coordination, and body coordination, and balance of MCI patients.

Relaxation Exercise

Exercise time: From 9:50 AM to 10:00 AM (10 minutes)

Venue: Outdoor plaza of the senior activity centre

Content:

The subjects were required to lie in a supine position with both legs shoulder width apart while breathing slowly and steadily. The subjects were then asked to tighten their muscles throughout their entire body and then relax them in certain areas in the subsequent order: the face, chin, neck, shoulders, chest, hands and arms, abdomen, back, buttock, thighs, legs, and feet. The exercise was repeated 3 times, taking 10 minutes to complete.

Objective:

Training in this stage was aimed at lowering the subjects’ arousal level, enhance their adaptability, and adjust cognitive dysfunction caused by anxiety. Relaxation training also assisted them in developing execution capability and physical coordination.

The limb exercise intervention was implemented through 3 weekly 60-minute sessions over a 10-week period, involving a total of 30 training sessions. For older adults, 9 AM to 10 AM is the optimal time for outdoor exercise. The agreeable air quality and temperature at this time ensures that their physical capabilities are in the most flexible state to adjust as deem necessary.

Intervention Procedures and Steps

(a) The researcher acquired permission and support from the administrators of the residential committees at Communities A, B and nursing home C, as well as the personnel in charge of Nursing home C and the senior activity centres in the residential quarters of Communities A and B. In addition, the researcher trained the assisting research personnel. Training was mainly focused on the intervention content and form of the limb exercise intervention project.

(b) We used a self-developed older adult demographic survey, the MMSE scale, and the ADL scale to screen elderly adults aged 60–70 years who lived in Communities A and B and Nursing home C in Daqing City. Patients with suspected MCI were screened according to their scale scores. These patients subsequently visited a psychiatrist to confirm MCI diagnosis.

(c) After the informed consent forms were obtained from the subjects, the 44 adults with diagnosed MCI were randomly grouped into a limb exercise training group and a control group, with 22 patients in each group.

(d) Subjects in the control group participated in regular activities at a community activity centre for seniors. MCI health education manuals were also distributed to these subjects. By comparison, the intervention group received exercise training in addition to the measures offered to the control group.

(e) In the first meeting, the subjects in the intervention group were informed of the time, content, schedule, and venue of the limb exercise training intervention.

(f) The researcher provided limb exercise training through the following measures:

Distributing information on the limb exercise training project:

According to the content of the limb exercise, the researcher drafted the training information and explanations.

Group training:

The limb exercise training group was divided into several subgroups, with 7 or 8 people in each group. In the first week, the researcher taught the limb exercise intervention items to the subjects. In addition, 3 trained staff members of the activity centres were selected as group heads.

Group exercises:

Beginning from the second week, the subjects were asked to participate in the limb exercise training intervention in groups. Training was held 3 times weekly, with each session lasting 60 minutes. In addition, the subjects were required to keep a record of their training conditions, and they were encouraged to perform additional training at home. The researcher and group heads monitored and instructed the subjects in each group.

Periodical visits or telephone visits:

The researcher maintained contact with the subjects and group heads, inquiring about the participation performance of the subjects in the intervention group.

Individual instructions:

The subjects were informed that if they had questions regarding the limb exercise training content or encountered any difficulty during the training process, they could inquire in person or over the telephone.

Evaluating observation indicators:

Intervention effect evaluation

First evaluation

When the MCI patients were identified, prior to conducting the formal intervention, the researcher measured the performance of both subject groups according to the related indicators, including a demographic survey, measurement of psychomotor speed (through FTT and PPT), and measurement of cognition level and EEG data collection.

Second evaluation

Five weeks after the intervention was completed, the performance of the subjects in both groups was measured according to the related indicators, as described in the first evaluation.

Third evaluation

Ten weeks after the intervention was completed, the subjects in both groups were measured according to the related indicators, as described in the first evaluation.

Table 3

Experiment procedure for limb exercise training

Group	**Measurement (Baseline)**	**Experiment conditions**	**Measurement (Week 5)**	**Measurement (Week 10)**
Training group	Demographics Psychomotor speed Cognition level EEG	Limb training exercise Regular activities Health education manual	Psychomotor speed Cognition level EEG	Psychomotor speed Cognition level EEG
Control group	Demographics Psychomotor speed Cognition level EEG	Regular activities Health education manual	Psychomotor speed Cognition level EEG	Psychomotor speed Cognition level EEG

Research Flowchart

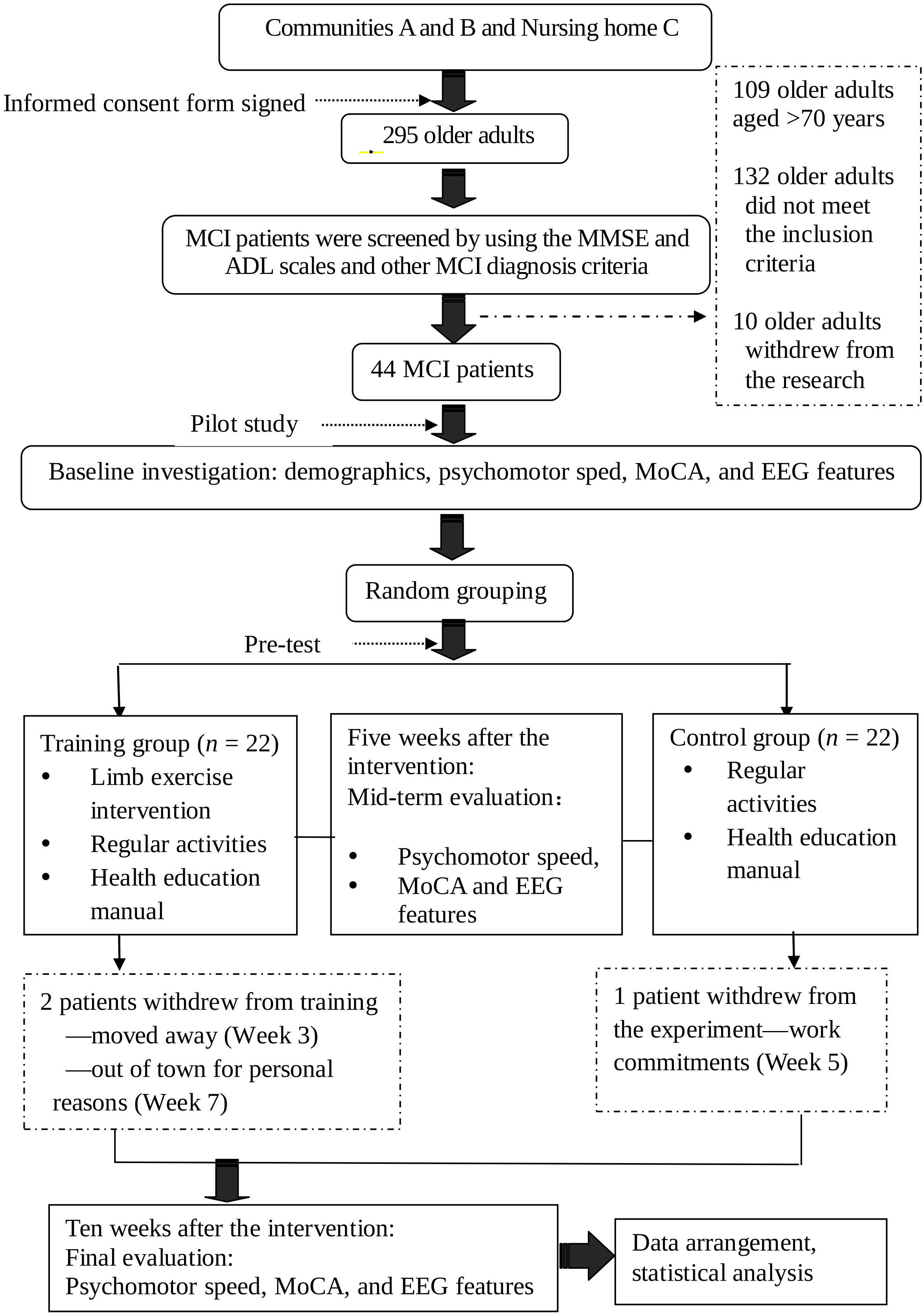


Figure 4 Research Flowchart

3.6 Data Analysis Procedures

This study used SPSS Version 18 to organise and analyse the data.

Demographic statistics

Measurement data that follow a normal distribution were described using the mean ± standard deviation; those data that follow a no normal distribution were described used the median value and quartiles. In addition, the count data were presented as frequencies and percentages.

Baseline level comparison between the limb exercise training group and the control group

The researcher adopted a $\chi 2$ test and independent samples t- test to compare the baseline levels of all variables in the subjects of the 2 groups. For measurements and ranked data following a no normal distribution, the Mann-Whitney U rank sum test, which is a nonparametric statistical method, was applied to balance the distribution of the related variables for both groups before the intervention.

The Relationship between psychomotor speed and cognition level

Spearman's rank correlation coefficient was applied to investigate the relationship between the subjects' psychomotor speed and cognition level.

Effect verification of the limb exercise intervention project

The researcher conducted a repeated measures analysis of variance (ANOVA) for both groups to identify any statistically significant differences in the subjects' psychomotor speed, MoCA, and EEG features to evaluate the influence of the limb exercise intervention project on the subjects' cognitive function.

In all of the aforementioned statistical tests, $P < 0.05$ was regarded as the level of statistical significance.

Chapter 4

RESULTS AND ANALYSIS

In this chapter, the researcher reports the findings of the exercise with regard to the impact of increased Structured Limbs exercise on the cognitive function of older adults.

In this research, 44 MCI patients were recruited and randomly divided into the limb training group (n = 22) and control group (n = 22). In the follow-up process, one subject in the limb training group dropped out from follow-up in Week 3 and another subject in the same group dropped out from follow-up in Week 7. In the control group, one subject dropped out from follow-up in Week 5. The total number of subjects dropped out from follow-up accounted for 6.81% of the total subjects recruited. The reasons for the 3 losses to follow-up were: one subject moved to another place during the research period and 2 subjects voluntarily withdrew from the research because of work commitments. Finally, complete data were collected from 41 subjects: 20 in the limb training group and 21 in the control group.

4.1 Demographic data of research subjects

Among the 41 subjects included in this study, 20 were in the training group, and 21 were in the control group. The demographic and clinical data of the research subjects (Table 4) show that the average age of the subjects was 65.22 ± 3.27 years and sex ratio was even. Most subjects were married (87.8%), among which 78% were Han Chinese. Most subjects were retired (65.9%), had an education background of junior high schools or above (51.3%), and had an average monthly household income equal to approximately RMB$1000–US$2000. More than half of the subjects lived with their spouses (56.1%), were non-smokers (56.1%), and consumed alcohol (61.0%). Most subjects (73.2%) had at least one chronic disease (coronary heart disease, hypertension, or diabetes), and slightly less than half rated their health condition as average (46.3%).

Comparisons were subsequently conducted against the baseline data for the training and control groups. An independent samples t test was used for the age variable. Sex, marital status, ethnicity, employment status, living conditions, smoking status, drinking status, and chronic disease status were examined using four-fold tables or Chi-square ($\chi2$) tests with contingency tables. Furthermore, education level, household monthly income and self-rated health conditions were examined using the Mann–Whitney U rank-sum tests (Z-test). Table 4 shows that the differences in the aforementioned indicators between the 2 groups were no significant ($P > 0.05$).

4.2 Correlational analysis of PS vs cognition level

According to the research setting, FTT involved 2 dimensions, the Purdue pegboard experiment involved 3 dimensions, and the MoCA involved 7 dimensions. Spearman's rank correlation coefficient was calculated for the 2 dimensions of the FTT, 3 dimensions of the PPT, and total score and individual dimension scores for the 7 dimensions of the MoCA test. Table 5 reveals that the all scores for the FTT and PPT dimensions are significantly related with those for the MoCA test (all $P <0.05$). In addition, FTT scores in all dimensions correlated to those for the PPT (all $P <0.05$)

Table 4
Demographic *and clinical data*

Indicator	Category	Research subject	Training group	Control group	t /χ^2	P
Age		65.22±3.27	64.95±3.41	65.48±3.19	-0.511	0.612
Sex	Male	21（51.22%）	9（45.00%）	12（57.14%）	0.605	0.437
	Female	20（48.78%）	11（55.00%）	9（42.86%）		
Marital status	Married	36（87.80%）	17（85.00%）	19（90.48%）	0.287	0.592
	Divorced or widowed	5（12.20%）	3（15.00%）	2（9.52%）		
Ethnicity	Han Chinese	32（78.00%）	16（80.00%）	16（76.19%）	0.087	0.768
	Other minority	9（22.00%）	4（20.00%）	5（23.81%）		
Employment status	Employed	14（34.15%）	6（30.00%）	8（38.10%）	0.299	0.585
	Unemployed	27（65.85%）	14（70.00%）	13（61.90%）		

Education level	Illiterate	8（19.51%）	4（20.00%）	4（19.05%）	-0.329	0.743
	Elementary school	12（29.27%）	5（25.00%）	7（33.33%）		
	Junior high school or above	21（51.22%）	11（55.00%）	10（47.62%）		
Household monthly income	≤ RMB1000	5（12.20%）	3（15.00%）	2（9.52%）	-0.710	0.478
	RMB$1,000 –RMB$2,000	19（46.34%）	10（50.00%）	9（42.86%）		
	RMB$2,000 –RMB$3,000	11（26.83%）	4（20.00%）	7（33.33%）		
	≥RMB$3,000	6（14.63%）	3（15.00%）	3（14.29%）		
Living conditions	Living alone	3（7.31%）	2（10.00%）	2（9.52%）	0.042	0.979
	Living with a spouse	23（56.10%）	11（55.00%）	11（52.38%）		
	Living with children	15（36.59%）	7（35.00%）	8（38.10%）		

Smoking status	Y	18（43.90%）	8（40.00%）	10（47.62%）	0.241	0.623
	N	23（56.10%）	12（60.00%）	11（52.38%）		
Drinking status	Y	25（60.98%）	12（60.00%）	13（61.90%）	0.016	0.901
	N	16（39.02%）	8（40.00%）	8（38.10%）		
Chronical disease (s)	Y	30（73.17%）	14（70.00%）	16（76.19%）	0.200	0.655
	N	11（26.83%）	6（30.00%）	5（23.81%）		
Self-rated health condition	Good	11（26.83%）	5（25.00%）	6（28.57%）	-0.421	0.674
	Average	19（46.34%）	11（55.00%）	8（38.10%）		
	Poor	11（26.83%）	4（20.00%）	7（33.33%）		

N = 41, $\overline{X}$ *±SD, number of people [%]*

Table 5

Correlation analysis on the dimensional and total scores of FTT, PPT, and MoCA

Item	FTT (left)	FTT (right)	Purdue pegboard (left)	Purdue pegboard (left)	Purdue pegboard (right)	Purdue pegboard (both)	Naming	Attention	Language	Abstraction	Delayed recall	Orientation	Total
FTT (left)	1.00												
FTT (right)	0.88**	1.00											
Purdue pegboard (left)	0.96**	0.83**	1.00										
Purdue pegboard (right)	0.86**	0.82**	0.88**	1.00									
Purdue pegboard (both)	0.73**	0.60*	0.78**	0.81**	1.00								
Visuospatial execution	0.83**	0.78**	0.83**	0.91**	0.75**	1.00							
Naming	0.66*	0.60*	0.66*	0.78**	0.56*	0.78**	1.00**						
Attention	0.74**	0.77**	0.80**	0.84**	0.64*	0.81**	0.74**	1.00					
Language	0.53*	0.49*	0.57*	0.66*	0.50*	0.57*	0.65*	0.52*	1.00				
Abstraction	0.71**	0.66*	0.78**	0.78**	0.59*	0.71**	0.65*	0.84**	0.50*	1.00			
Delayed recall	0.80**	0.78**	0.83**	0.89**	0.75**	0.81**	0.77**	0.80**	0.66*	0.77**	1.00		
Orientation	0.65*	0.53*	0.73**	0.74**	0.63*	0.69*	0.69*	0.66*	0.63*	0.63*	0.70**	1.00	
Total	0.83**	0.79**	0.87**	0.94**	0.74**	0.90**	0.86**	0.91**	0.74**	0.85**	0.93**	0.79**	1.00

*Note: * denotes P <0.01, ** and P <0.001*

4.3 Typical characteristics of EEG Observed among MCI Patients

This study examined and analyzed the basic components of EEG images obtained from 41 MCI patients, including frequency, amplitude, waveform and rhythm. The results revealed that, in these EEG images, the alpha rhythms slowed, the alpha wave activities decreased, and the alpha amplitudes declined. As the alpha index decreased, the alpha wave activities slowed and even levelled. By comparison, the beta activities slightly decreased, and the theta activities increased moderately (Figure 5).

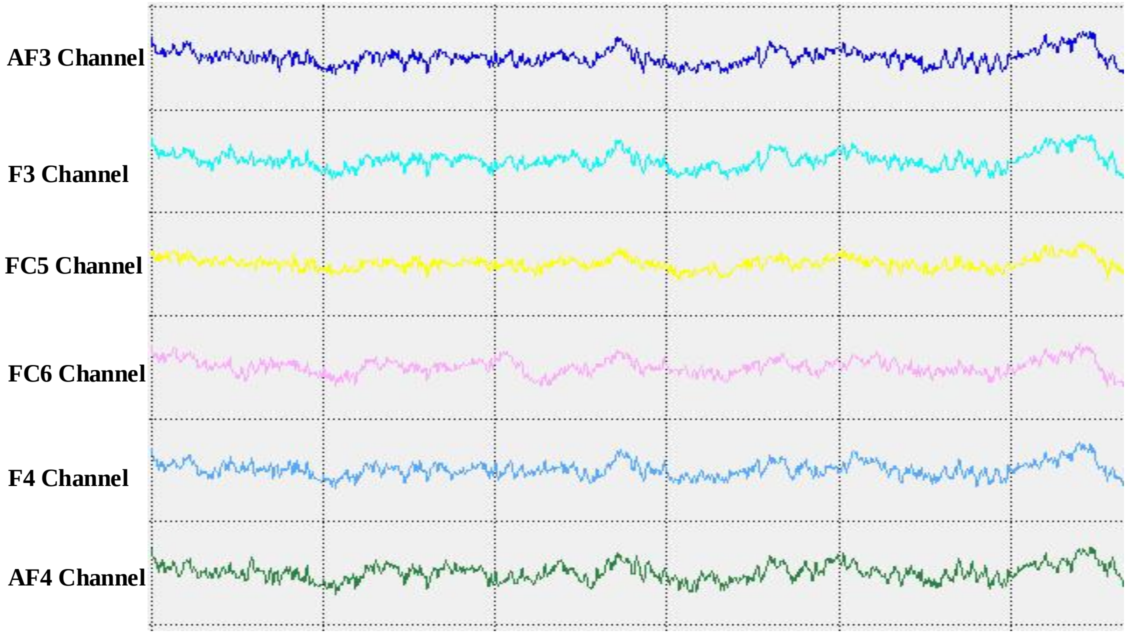


Figure 5. 6-channel EEG waveforms of a female subject.

4.4 Verifying the effects of the limb exercising training intervention on enhancing the cognition level of the MCI patients

4.4.1 Influences of the limb exercising training intervention on the PS of the MCI patients

a. *Balance comparison of the psychomotor speed of the 2 groups before the intervention*

Before the intervention, the researcher conducted the FTT and PPT to examine the psychomotor speed of the research subjects. The results show that on average, the subjects tapped their fingers for 45.00 ± 5.43 times with their left hand and 48.39 ± 4.86 times with the right hand. No statistical significance was observed in the test results between the 2 groups (all P >0.05). The PPT results revealed that the average number of pegs inserted correctly by the left, right, and both hands were 12.27 ± 1.80, 13.22 ± 1.93, and 10.75 ± 1.51, respectively. The results revealed no statistical significance between the 2 groups (all P >0.05), indicating that the subjects in the 2 test groups attained balanced results for the FTT and PPT, and that the 2 groups were comparable (Table 6).

Table 6

Psychomotor Speed (N = 41, and $\overline{X}$ ± SD)

Item	All subjects	Training group	Control group	*t* value	*P* value
FTT					
FTT (left)	45.00±5.43	45.60±5.45	44.43±5.48	0.686	0.497
FTT (right)	48.39±4.86	48.40±5.11	48.38±4.72	0.012	0.990
PPT					
PPT (left)	12.27±1.80	12.50±1.96	12.05±1.66	0.799	0.429
PPT (right)	13.22±1.93	13.15±1.98	13.29±1.93	-0.222	0.825
PPT (both)	10.75±1.51	10.85±1.42	10.67±1.62	0.384	0.703

b. Psychomotor speed of the research subjects at various time points

The psychomotor speed of the research subjects in the 2 groups was evaluated using FTT and PPT at baseline, Week 5, and Week 10. The results show that at the end of Week 10, the limb exercise training group attained higher scores in the 2 dimensions of FTT and 3 dimensions of PPT compared with the baseline measurements. By comparison, the increase in scores for the 2 dimensions of FTT and 3 dimensions of PPT observed in the control group was less notable. Tables 7 and

8 show the FTT and PPT scores, respectively.

Table 7

FTT scores before and after intervention (N = 41, and $\overline{X} \pm SD$*)*

Item	Dimension	Baseline	Week 5	Week 10
Training group	FTT (left)	45.60±5.45	49.95±4.59	54.75±6.19
	FTT (right)	48.40±5.11	51.90±4.75	57.05±6.80
Control group	FTT (left)	44.43±5.48	45.52±5.15	47.62±5.71
	FTT (right)	48.38±4.72	48.19±4.25	50.52±6.02

Table 8

PPT scores before and after intervention (N = 41, and $\overline{X} \pm SD$*)*

Item	Dimension	Baseline	Week 5	Week 10
Training group	PPT (left)	12.50±1.96	14.75±2.24	16.65±2.66
	PPT (right)	13.15±1.98	15.85±2.78	18.40±3.41
	PPT (both)	10.85±1.42	12.70±2.25	14.45±2.72
Control group	PPT (left)	12.05±1.66	12.80±2.18	13.71±2.61
	PPT (right)	13.29±1.93	13.86±2.49	15.00±3.21
	PPT (both)	10.67±1.62	11.24±1.92	11.81±2.23

c. Evaluation of the Intervention Effects

A 2-way multilevel ANOVA of repeated measures test was conducted to evaluate the improvement in the psychomotor speed in the 2 groups at baseline, Week 5, and Week 10. The between-group factor was the grouping (i.e., training vs control); the within-group factor was the measurement time (i.e., baseline, Week 5, and Week 10); and the interaction effect was measured by group × time.

Comparing the FTT scores of both subject groups before and after the intervention

Analyzing the effects and interaction effects of time and grouping

The study adopted Mauchly's test of sphericity to determine whether the repeated data measurements were correlated. As shown in Table 9 the test result exhibited P < .05, indicating a high correlation among the data collected through the 3 repeated measurements. After the epsilon value was corrected by applying the Greenhouse-Geisser procedure, the coefficients were all >0.7, suggesting that repeated measures ANOVA can be conducted.

Table 9

Mauchly's test of sphericity results

Item	Within subject effect	Mauchly' W	Approx. Chi Square	df	Sig.	Epsilon Greenhouse-Geisser	Huynh-Feldt	Lower bound
FTT (left)	Time	.597	19.626	2	.000	.713	.751	.500
FTT （right）	Time	.472	28.490	2	.000	.655	.686	.500

The results of within-subject tests revealed that the time factor generated a statistically significant difference in the measured indicators (FTT left and right) over time. In addition, the interaction between time and grouping had a statistically significant effect (P <0. 01), indicating that time influenced the subjects differently according to which group they were in. In other words, the measurement time influenced the 2 groups differently according to the FTT scores for the subjects' right and left hands (Table 10).

Table 10

Within-subject test scores

Source	Item	Type Ⅲ sum of squares	df	Mean square	*F*	Sig.
time	FTT (left)	783.598	2	391.799	82.808	.000
	FTT (right)	626.377	2	313.189	39.262	.000
time * group	FTT (left)	182.427	2	91.214	19.278	.000
	FTT (right)	218.182	2	109.091	13.676	.000
Error (time)	FTT (left)	369.052	78	4.731		
	FTT (right)	622.192	78	7.977		

The results of the between-subject test show that the grouping factor exerted a significant influence on the total FTT score obtained by the 2 groups ($P < 0.05$), as shown in Table 11.

Table 11

Between-subject effects test

Source	Item	Type Ⅲ sum of squares	df	Mean square	F	Sig.
Intercept	FTT (left)	282970.593	1	282970.593	3546.475	0.000
	FTT (right)	316491.864	1	316491.864	4546.649	0.000
Group	FTT (left)	553.227	1	553.227	6.934	0.012
	FTT (right)	359.083	1	359.083	5.159	0.029
Error	FTT (left)	3111.781	39	79.789		
	FTT (right)	2714.787	39	69.610		

Run charts were plotted to present the indicators at the 3 measurement times. Figures 6 and 7 show the trends in FTT scores of the 2 subject groups for the left and right hands, respectively. In particular, the training group exhibited a more noticeable improvement over time.

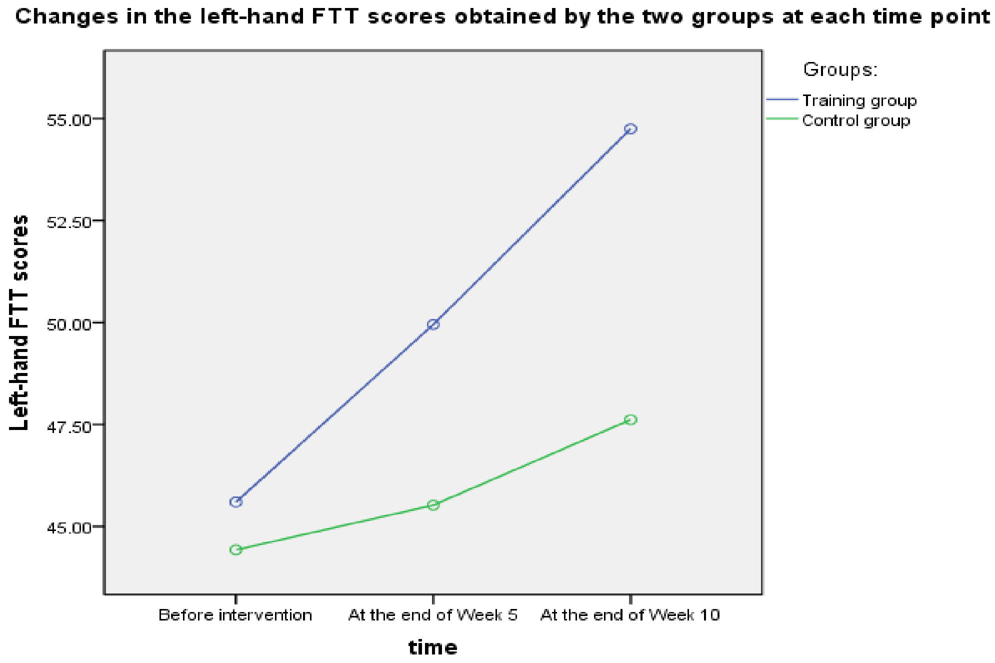


Figure 6 Changes in the left-hand FTT scores obtained by the two groups at each time point

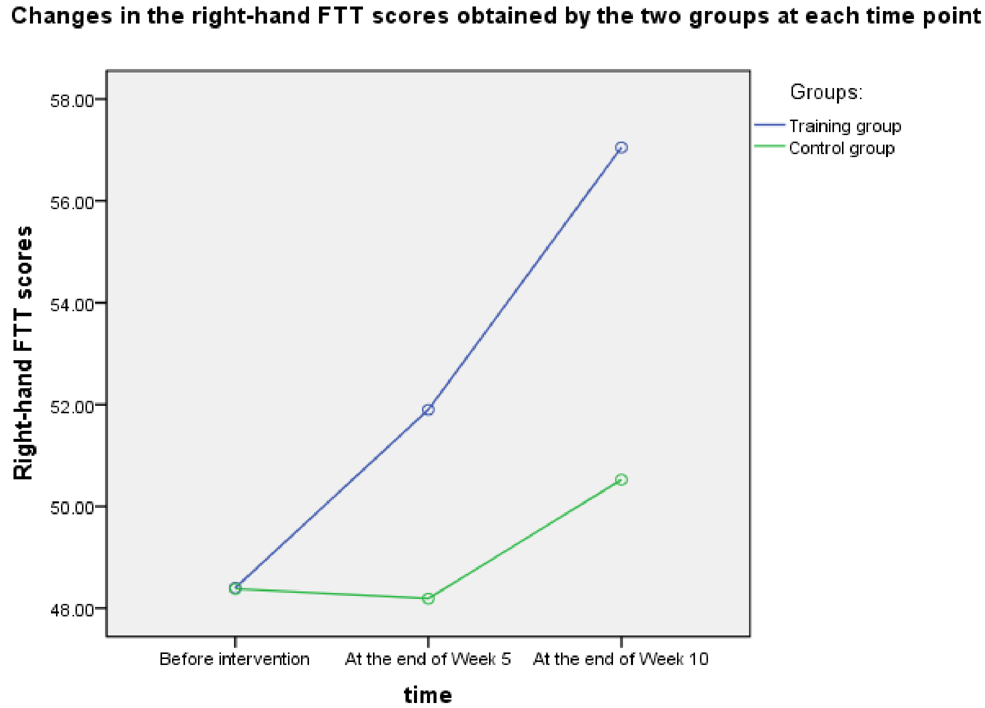


Figure 7 Changes in the right-hand FTT scores obtained by the two groups at each time point.

Between-group comparison of FTT scores obtained by the 2 groups at various time points

Before the intervention, the difference in the FTT scores between the 2 subject groups was nonsignificant for the left hand. At Week 5, compared with the control group, the limb exercise training group obtained significantly higher FTT scores for the left hand (P < 0.05). At Week 10, the limb exercise training group exhibited an even more significant improvement in FTT scores for the left hand FTT (P < 0.01). These results suggest that limb exercise training significantly enhanced the psychomotor speed of the MCI patients (Table 12).

Table 12

Between-group comparison of FTT scores of both groups measured at various time points

Group	**Category**	**Measurement times**		
		Baseline	**Week 5**	**Week 10**
Training group	FTT (left)	45.60±5.45	49.95±4.59	54.75±6.19
	FTT (right)	48.40±5.11	51.90±4.75	57.05±6.80
Control group	FTT (left)	44.43±5.48	45.52±5.15	47.62±5.71
	FTT (right)	48.38±4.72	48.19±4.25	50.52±6.02
t	FTT (left)	0.686	2.898	3.833
	FTT (right)	0.012	2.640	3.257
p	FTT (left)	0.497	0.006	0.000
	FTT (right)	0.990	0.012	0.002

Within-group comparison of FTT scores of both groups measured at various time points

Within-group comparison of FTT scores of both groups measured at various time points

Table 13 is a within-group comparison of the FTT scores of the training and control groups measured at the various time points. Least significant difference (LSD) was employed to compare the conditions of the subjects at the 3 measurement timers: baseline (S_0) to Week 5 (S_1); baseline (S_0) to Week 10 (S_2); and from the end of Week 5 (S_1) to the end of Week 10 (S_2). The results show that in the exercise training intervention group, except for the nonsignificant differences between the right-hand FTT scores between S_0 and S_1, significant differences were observed in the comparisons of left- and right-hand FTTs between all measurement times (all $P < 0.05$). Furthermore, the FTT scores observed at Week 10 are significantly higher than those at Week 5 ($P_{\text{left}} = 0.007$, $P_{\text{right}} = 0.005$). By comparison, the control group exhibited no statistically significant differences in the FTT scores between the different measurement points (all $P > 0.05$). These results indicate that the limb exercise training intervention had a positive influence on the psychomotor speed of the MCI patients and improved their FTT scores.

Table 13

Within-group comparison of FTT scores of both groups measured at various time points.

Category	Group	Time point	$\overline{X} \pm S$	S_0–S_1		S_0–S_2		S_1–S_2	
				Mean difference	***P***	**Mean difference**	***P***	**Mean difference**	***P***
FTT (left)	Training group	S_0	45.60±5.45	-4.350	0.014	-9.150	0.000	-4.800	0.007
		S_1	49.95±4.59						
		S_2	54.75±6.19						
	Control group	S_0	44.43±5.48	-1.095	0.518	-3.190	0.063	-2.095	0.218
		S_1	45.52±5.15						
		S_2	47.62±5.71						
FTT (right)	Training group	S_0	48.40±5.11	-3.500	0.054	-8.650	0.000	-5.150	0.005
		S_1	51.90±4.75						
		S_2	57.05±6.80						
	Control group	S_0	48.38±4.72	0.190	0.903	-2.142	0.175	-2.333	0.140
		S_1	48.19±4.25						
		S_2	50.52±6.02						

Analyzing the effects of time and grouping and the interaction effect between these 2 factors

The study adopted Mauchly's test of sphericity to determine whether the repeated data measurements were correlated. As shown in Table 14, the test result exhibited $P < .05$, indicating a high correlation among the data collected through the 3 repeated measurements. After the epsilon value was corrected by applying the Greenhouse-Geisser procedure, the coefficients were all >0.7, indicating that repeated measures ANOVA can be performed.

The statistical results of within-subjects tests revealed that the time factor exerted a statistically significant influence on the measurement results (PPT left and right) over time ($P < 0.01$). In addition, the interaction between the time and grouping achieved statistical significance ($P < 0.01$), indicating that time influenced the subjects differently according to which group they were in. In other words, the time of measurement influenced the 2 groups differently according to the PPT scores for the right, left, and both hands (Table 15).

The results of between-subject difference reveals that the grouping factor affected the 2 groups differently according to the PPT scores for the subjects' left, right, and both hands, as shown in Table 16 ($P < 0.05$).

Run charts were plotted to present the variation in the indicators measured at the 3 measurement times. Figures 8，9 and 10 show the trends in the PPT scores obtained by both groups when testing the left, right, and both hands. In particular, the charts show that the training group exhibited a more noticeable improvement over time.

Table 14

Mauchly's test of sphericity

Item	Within subject effect	Mauchly' W	Approx. Chi Square	df	Sig.	Epsilon Greenhouse-Geisser	Huynh-Feldt	Lower bound
PPT (left)	Time	0.457	29.734	2	.000	0.648	0.678	0.500
PPT (right)	Time	0.367	38.091	2	.000	0.612	0.638	0.500
PPT (both)	Time	0.538	23.581	2	.000	0.684	0.718	0.500

Table 15

Tests of within-subject effects

Source	Item	Type Ⅲ sum of squares	df	Mean square	*F*	Sig.
time	PPT (left)	173.367	2	86.684	93.740	0.000
	PPT (right)	248.724	2	124.362	85.364	0.000
	PPT (both)	115.234	2	57.617	58.630	0.000
time * group	PPT (left)	32.002	2	16.001	17.303	0.000
	PPT (right)	64.920	2	32.460	22.281	0.000

	PPT (both)	30.941	2	15.471	15.743	0.000
Error (time)	PPT (left)	72.129	78	0.925		
	PPT (right)	113.633	78	1.457		
	PPT (both)	76.652	78	0.983		

Table 16

Tests of between-subject effects

Source	Item	Type Ⅲ sum of squares	df	Mean square	F	Sig.
Intercept	PPT (left)	23224.759	1	23224.759	1749.773	0.000
	PPT (right)	27378.275	1	27378.275	1456.443	0.000
	PPT (both)	17561.254	1	17561.254	1612.407	0.000
Group	PPT (left)	96.954	1	96.954	7.305	0.010
	PPT (right)	94.372	1	94.372	5.020	0.031
	PPT (both)	62.718	1	62.718	5.759	0.021
Error	PPT (left)	517.648	39	13.273		
	PPT (right)	733.124	39	18.798		
	PPT (both)	424.762	39	10.891		

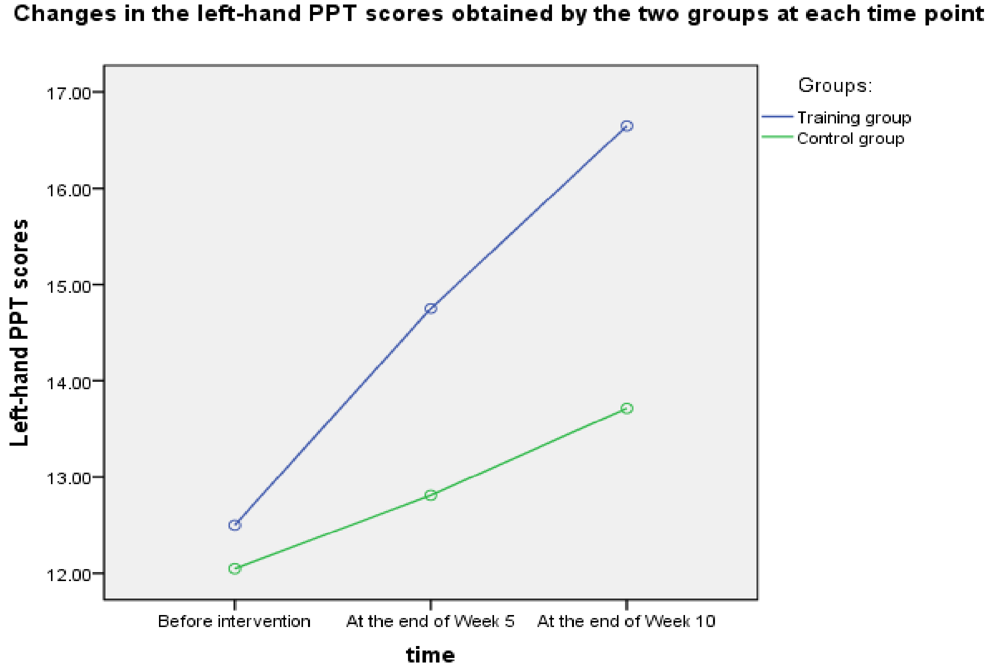


Figure 8. Changes in the left-hand PPT scores obtained by the two groups at each time point.

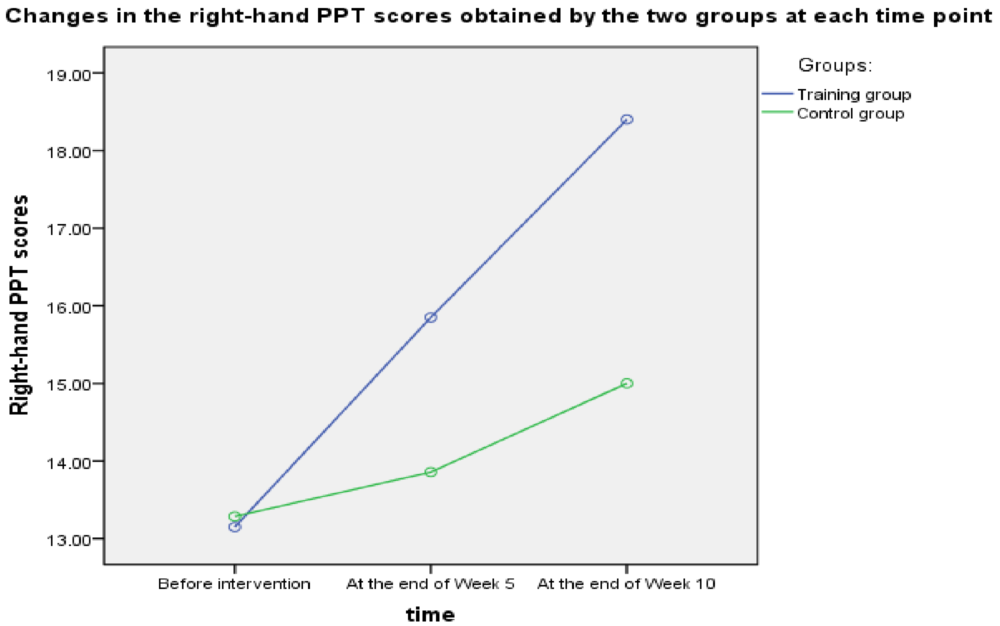


Figure 9. Changes in the right-hand PPT scores obtained by the two groups at each time point.

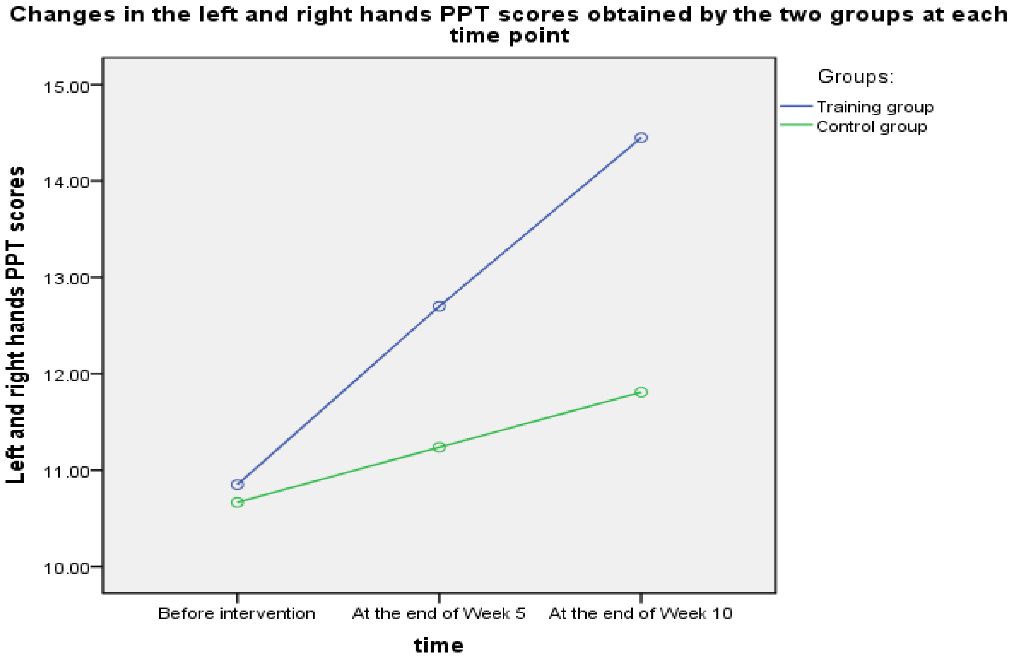


Figure 10. Changes in the left and right hands PPT scores obtained by the two groups at each time point.

Between-group comparison of PPT scores of both groups measured at various time points

At baseline, the difference in PPT scores between the 2 groups for the left, right, and both hands were no significant. At Week 5, compared with the control group, the limb exercise training group attained significantly higher PPT scores for their left, right, and both hands (P <0.05). At Week 10, the limb exercise training group achieved an even more significant increase PPT scores for the left, right, and both hands (P < 0.01). These results suggest that the limb exercise training intervention significantly enhanced the psychomotor speed of the MCI patients (Table 17).

Table 17

Between-group comparison of PPT scores of both groups measured at various time points

Group	Category	Measurement times		
		Baseline	Week 5	Week 10
Training group	PPT (left)	12.50±1.96	14.75±2.24	16.65±2.66
	PPT (right)	13.15±1.98	15.85±2.78	18.40±3.41
	PPT (both)	10.85±1.42	12.70±2.25	14.45±2.72
Control group	PPT (left)	12.05±1.66	12.80±2.18	13.71±2.61
	PPT (right)	13.29±1.93	13.86±2.49	15.00±3.21
	PPT (both)	10.67±1.62	11.24±1.92	11.81±2.23
t	PPT (left)	0.799	2.807	3.566
	PPT (right)	-0.222	2.419	3.290
	PPT (both)	0.384	2.241	3.405
p	PPT (left)	0.429	0.008	0.001
	PPT (right)	0.825	0.020	0.002
	PPT (both)	0.703	0.031	0.002

Within-group comparison of PPT scores of both groups measured at various time points.

Table 18 compares the within-group PPT scores for both the training and control groups measured at various time points. LSD was employed to compare the conditions according to method for the within-group comparison. The results reveal that in the exercise training intervention group, significant differences are observed in the PPT results among the left, right, and both hands at all measurement points (all $P < 0.05$). Furthermore, the PPT scores at Week 10 are significantly higher than those at Week 5 ($P_{left} = 0.012$, $P_{right} = 0.005$, $P_{both} = 0.015$). By comparison, in the control group, except for the nonsignificant right-hand PPT scores between S_0 and S_2 ($P_{right} = 0.037$), all other within-subjects PPT scores did differ statistically among the measurement times (all $P > 0.05$). These results indicate that the limb exercise training intervention had a positive influence on the psychomotor speed of the MCI patients as and significantly improved their PPT scores.

Table18

Within-group comparison of PPT scores of both groups measured at various time points

Category	Group	Time point	$\overline{X} \pm S$	$S_0 \sim S_1$		$S_0 \sim S_2$		$S_1 \sim S_2$	
				Mean difference	*P*	Mean difference	*P*	Mean difference	*P*
PPT (left)	Training group	S_0	12.50±1.96	-2.250	0.003	-4.150	0.000	-1.900	0.012
		S_1	14.75±2.24						
		S_2	16.65±2.66						
	Control group	S_0	12.05±1.66	-0.762	0.263	-1.167	0.059	-0.905	0.185
		S_1	12.80±2.18						
		S_2	13.71±2.61						
PPT (right)	Training group	S_0	13.15±1.98	-2.700	0.003	-5.250	0.000	-2.550	0.005
		S_1	15.85±2.78						
		S_2	18.40±3.41						
	Control group	S_0	13.29±1.93	-0.571	0.479	-1.714	0.037	-1.143	0.159
		S_1	13.86±2.49						
		S_2	15.00±3.21						
PPT (both)	Training group	S_0	10.85±1.42	-1.850	0.010	-3.600	0.000	-1.750	0.015
		S_1	12.70±2.25						
		S_2	14.45±2.72						

Control group	S_0	10.67 ±1.62	-0.571	0.344	-1.143	0.061	-0.571	0.344
	S_1	11.24 ±1.92						
	S_2	11.81 ±2.23						

4.4.2 Influence of the Limb Exercise Training Intervention on the Cognition Level of the MCI Patients

a. Between-group comparison of the subjects' cognitive function at baseline

Before the intervention, the Beijing version of MoCA was employed to measure the subjects' cognition level. The results revealed that the subjects' attained an average total score of 17.15 ±4.53. Table 19 shows that statistically significant difference was observed between 2 groups in the scores for visuospatial execution, naming, attention and calculation, language, abstraction, delayed recall, and orientation (all P >0.05).

The Beijing version of MoCA covers the following cognitive areas: visuospatial and executive capacity (5 points), naming (3 points), attention and calculation (6 points), language (3 points), abstraction (2 point), delayed recall (5 points), and orientation (6 points).

b. Cognition levels at different measurement times

The Beijing version of the MoCA was adopted to evaluate the cognition levels of the groups at baseline, Week 5, and Week 10. The results show that at Week 10, MoCA scores of the limb exercise training intervention group were relatively higher compared with the baseline scores. By comparison, although the control group's scores increased, the increase was comparatively smaller (Table 20).

Table 19

Baseline cognition level (N=41 and $\overline{X}$ *±S)*

Item	Research subject	Training group	Control group	t value	*P* value
visuospatial execution	2.66±1.09	2.65±1.14	2.67±1.06	-0.048	0.962
Naming	2.37±0.58	2.40±0.50	2.33±0.66	0.363	0.718
Attention and calculation	2.80±0.78	2.80±0.83	2.57±0.67	0.967	0.967
Language	2.31±0.65	2.25±0.64	2.38±0.67	-0.640	0.526
Abstraction	1.44±0.63	1.45±0.69	1.43±0.59	0.107	0.916
Delayed recall	2.41±0.92	2.35±0.93	2.47±0.92	-0.434	0.667
Orientation	3.07±0.61	3.15±0.67	3.00±0.55	0.786	0.437
Total	17.15±4.53	17.15±4.67	17.14±4.49	0.005	0.996

Table 20

MoCA scores at the different measurement times (N = 41, and $\overline{X} \pm SD$*)*

Item	Training group			Control group		
	Baseline	Week 5	Week 10	Baseline	Week 5	Week 10
visuospatial execution	2.65±1.14	3.40±1.05	3.85±1.09	2.67±1.06	2.86±1.06	2.95±1.12
Naming	2.40±0.50	2.70±0.66	3.55±1.09	2.33±0.66	2.52±0.75	2.67±0.86
Attention and calculation	2.80±0.83	3.10±1.07	3.60±0.99	2.57±0.67	2.67±0.79	2.81±0.81
Language	2.25±0.64	2.65±0.81	3.30±0.73	2.38±0.67	2.57±0.59	2.76±0.62
Abstraction	1.45±0.69	1.70±0.57	1.80±0.62	1.43±0.59	1.29±0.56	1.29±0.64
Delayed recall	2.35±0.93	2.70±1.03	3.25±0.91	2.47±0.92	2.57±0.93	2.67±0.79
Orientation	3.15±0.67	3.35±0.67	3.65±0.59	3.00±0.55	3.05±0.67	3.19±0.60
Total	17.15±4.67	19.65±3.92	23.00±2.81	17.14±4.49	17.52±3.89	18.33±3.59

c. Evaluating the intervention effects

A 2-way multilevel repeated measures ANOVA was conducted using the MoCA total scores obtained by the 2 groups at baseline, Week 5, and Week 10. The between-group factor was grouping (i.e., training vs control groups); the within-group factor was time (i.e., baseline, Week 5, and Week 10); and the interaction was group × time.

Analysis of the interaction effects of time and grouping

The study applied Mauchly's test of sphericity to determine whether the repeated data measurements were correlated. As shown in Table 21, the test result exhibited $P < .05$, indicating a high correlation among the data collected through the 3 repeated measurements. After the epsilon value was corrected by applying the Greenhouse-Geisser procedure, the coefficient was 0.734 (>0.7), meaning that the analysis could proceed to repeated measures ANOVA.

The statistical results of within-subjects tests revealed that the time factor had a statistically significant influence on the measurement results of MoCA indicators over time ($P < 0.01$). In addition, the interaction between time and grouping was statistically significant (P <0. 01), indicating that time influenced the subjects differently according to which group they were in. In other words, the time of measurement influenced the 2 groups differently in their total MoCA scores (Table 22).

As shown in Table 23, the results of the within-subjects test reveals that the grouping factor had a nonsignificant influence on the total MoCA scores obtained by the 2 groups ($P > 0.05$).

Table 21

Mauchly's test of sphericity

Item	Within subject effect	Mauchly' W	Approx. Chi Square	df	Sig.	Epsilon		
						Greenhouse-Geisser	Huynh-Feldt	Lower bound
MoCA scores	Time	0.638	17.063	2	0.000	0.734	0.776	0.500

Table 22

Tests of within-subject effects

Item	Source	Type III sum of squares	df	Mean square	*F*	Sig.
MoCA scores	time	256.677	2	128.339	58.480	0.000
	time * group	111.507	2	55.753	25.405	0.000
	Error (time)	171.176	78	2.195		

Table 23

Tests of between-subject effects

Item	Source	Type Ⅲ sum of squares	df	Mean square	F	Sig.
MoCA scores	Intercept	43447.259	1	43447.259	1025.444	.000
	Group	157.893	1	157.893	3.727	.061
	Error	1652.400	39	42.369		

Run charts were plotted to present the indicators measured at the 3 measurement times. Figure 13 depicts the trends of the MoCA total scores obtained by the 2 groups. In particular, the charts show that the training intervention group achieved a more noticeable improvement over time (Figure 11).

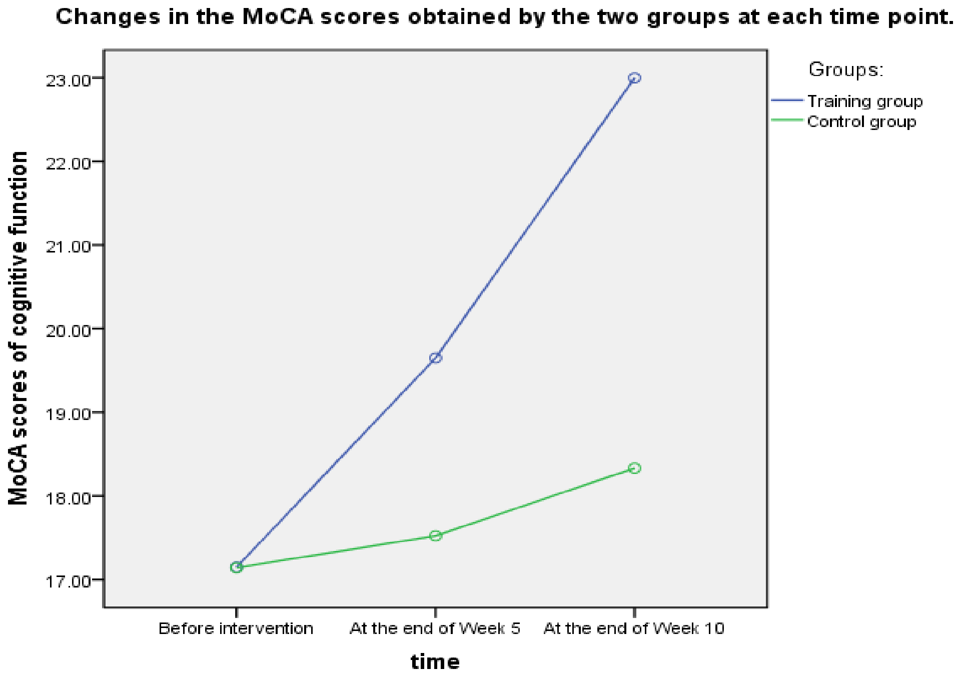


Figure 11. Changes in the MoCA scores obtained by the two groups at each time point.

Between-group comparison of the MoCA scores at different measurement times

At baseline, the differences in the MoCA scores between the 2 groups were nonsignificant. At Week 5, the limb exercise training intervention group had higher MoCA scores compared with the baseline scores, but the improvement in scores did not differ significantly from the improvement achieved by the control group (t = 1.741, P = 0.090). At Week 10, the MoCA scores obtained by the limb exercise training intervention group differed significantly from those obtained by the control group (P < 0.01). These results indicate that over time, the limb exercise training intervention had a more significant effect in enhancing the cognition levels of the MCI patients (Table 24).

Table 24

Between-group comparison of the MoCA scores at different measurement times

Item	Group	Measurement times		
		Baseline	Week 5	Week 10
MoCA scores	Training group	17.15±4.67	19.65±3.92	23.00±2.81
	Control group	17.14±4.49	17.52±3.89	18.33±3.59
	t	0.005	1.741	4.614
	p	0.996	0.090	0.000

Between-group comparison of the MoCA scores at different measurement times

Table 25 shows the within-group MoCA scores of the 2 groups measured at various time points. LSD was employed to compare the MoCA scores obtained by the subjects as described previously. The results show that between S_0 and $S_{1,}$ the training group achieved a relatively small but statistically significant improvement in MoCA scores (P = 0.046), although those at Week 10 were significantly higher than those at Week 5 (P = 0.008). Comparatively, the improvements in MoCA scores in the control group measured at the various time points were nonsignificant (all P >0.05). These results indicate that the limb exercise training intervention improved the MoCA scores in the training intervention group only, and that the training positively influenced the cognitive function of the MCI patients.

Table 25

Within-group comparison of MoCA scores measured at various time points

Item	Group	Time point	$\overline{X} \pm S$	$S_0 \sim S_1$		$S_0 \sim S_2$		$S_1 \sim S_2$	
				Mean difference	*P*	Mean difference	*P*	Mean difference	*P*
MoCA scores	Training group	S_0	17.15±4.67	-2.500	0.046	-5.850	0.000	-3.350	0.008
		S_1	19.65±3.92						
		S_2	23.00±2.81						
	Control group	S_0	17.14±4.49	-0.381	0.759	-1.190	0.340	-0.809	0.516
		S_1	17.52±3.89						
		S_2	18.33±3.59						

4.4.3 Effect of Limb Exercise Training on the EEGs Obtained from MCI Patients

a. Balance Comparison of the Preintervention Alpha- and Beta-Wave Power Values Between the Two Subject Groups

Before the intervention, the EEGs of the two subject groups were measured using an Emotiv EPOC neuroheadset. The results revealed that, in all brain areas, the power of the alpha and beta waves (all $P > .05$) of the two subject groups differed no significantly. Before the intervention, the two subject groups showed mostly consistent EEG power in all of the wavebands, as shown in Table 26.

b. Changes in the Power of the Alpha and Beta EEG Waves Measured in the Subjects at Several Time Points During the Intervention

The study adopted an Emotiv EPOC neuroheadset for measuring the power values in the alpha and beta EEG wavebands of the two subject groups, repeating the measurement before the intervention and at the end of Weeks 5 and 10 of the intervention; furthermore, the study evaluated changes in the power values observed in all of the brain areas. The results showed that the Week 10 measurements of the limb-exercise training group registered substantially higher power values in the alpha and beta EEG wavebands than did the pre-intervention measurements. By contrast, the power values of the alpha and beta waves obtained in the control group at the end of Week 10 showed a lower magnitude of increase compared with those measured before the intervention, as shown in Table 27.

Table 26

Comparison of the Alpha- and Beta-Wave Power in All Brain Areas (N = 41; $\overline{X} \pm S$)

Brainwave band	Research subjects	Training group	Control group	t value	*P* value
alpha_hemi_left	0.0050±0.0014	0.0052±0.0011	0.0048±0.0016	0.888	0.380
alpha_hemi_right	0.0058±0.0022	0.0057±0.0022	0.0059±0.0021	-0.167	0.868
alpha_region_front	0.0058±0.0019	0.0056±0.0014	0.0059±0.0022	-0.504	0.617
alpha_region_central	0.0058±0.0019	0.0057±0.0021	0.0059±0.0016	-0.279	0.781
beta_hemi_left	0.0088±0.0088	0.0091±0.0017	0.0086±0.0023	0.712	0.480
beta_hemi_right	0.0088±0.0088	0.0087±0.0027	0.0089±0.0023	-0.276	0.784
beta_region_front	0.0083±0.0083	0.0084±0.0016	0.0083±0.0021	0.169	0.867
beta_region_central	0.0098±0.0099	0.0099±0.0035	0.0098±0.0031	0.133	0.895

Table 27

Pre- and Post-Intervention Changes in the Alpha- and Beta-Wave Power of All Brain Areas of the Subjects (N = 41; $\overline{X} \pm S$*)*

Item	Training group			Control group		
	Baseline	Week 5	Week 10	Baseline	Week 5	Week 10
alpha_hemi_left	0.0052±0.0011	0.0062±0.0029	0.0088±0.0029	0.0048±0.0016	0.0059±0.0032	0.0059±0.0029
alpha_hemi_right	0.0057±0.0022	0.0067±0.0019	0.0088±0.0028	0.0059±0.0021	0.0059±0.0032	0.0060±0.0028
alpha_region_front	0.0056±0.0014	0.0064±0.0019	0.0088±0.0022	0.0059±0.0022	0.0060±0.0029	0.0060±0.0019
alpha_region_central	0.0057±0.0021	0.0067±0.0029	0.0089±0.0034	0.0059±0.0016	0.0060±0.0026	0.0060±0.0029
beta_hemi_left	0.0091±0.0017	0.0133±0.0021	0.0224±0.0048	0.0086±0.0023	0.0104±0.0026	0.0144±0.0041
beta_hemi_right	0.0087±0.0027	0.0132±0.0022	0.0232±0.0039	0.0089±0.0023	0.0105±0.0016	0.0145±0.0040
beta_region_front	0.0084±0.0016	0.0121±0.0021	0.0213±0.0044	0.0083±0.0021	0.0095±0.0019	0.0137±0.0032
beta_region_central	0.0099±0.0035	0.0155±0.0028	0.0259±0.0057	0.0098±0.0031	0.0123±0.0027	0.0160±0.0043

c. Evaluation of the Intervention Effects

A 2-way, multilevel, repeated measures ANOVA was conducted on the power of the alpha and beta EEG waves measured from the training and control group subjects at different time points, including before the intervention and at the end of Weeks 5 and 10. The between-groups factor was the grouping (ie, the training and control groups), and the within-group factor was time (ie, before the intervention and at the end of Weeks 5 and 10 of the intervention), with the interaction being grouping × time.

Pre- and Postintervention total scores of both subject groups for the alpha-wave power values in all brain areas

Analysing the effects of and interaction between time and grouping

The study adopted Mauchly's test of sphericity to determine whether the repeated data measurements were correlated. Except for the test result of the alpha_region_ central waveband ($P < .05$), the test results for other brain areas were all $P > .05$, indicating no correlation among the data collected through the 3 repeated measurements. Therefore, repeated measures ANOVA can be conducted to analyse the data. The sphericity result of the alpha_region_ central waveband was $P < .05$. After the epsilon value was corrected by applying the Greenhouse-Geisser procedure, the coefficient was 0.828 (>0.7), suggesting that the analysis could proceed to repeated measures ANOVA. The Mauchly's test of sphericity results are shown in Table 28.

The statistical results of the within-subject tests revealed that the time factor generated statistical significance ($P < .01$) and that the measured indicators (power of the alpha waves in all brain areas) changed over time. In addition, the interaction between time and grouping (time × grouping) achieved statistical significance ($P < .01$), which indicated that the effects of time factors on the subjects differed between the two groups. In other words, the effects of measurement time on the alpha-wave power values in the brain areas of the two groups differed (Table 29).

Table 28

Mauchly's test of sphericity

Item	Within subject effect	Mauchly' W	Approx. Chi Square	df	Sig.	Epsilon		
						Greenhouse-Geisser	Huynh-Feldt	Lower bound
alpha_hemi_left	Time	0.918	3.268	2	0.195	0.924	0.993	0.500
alpha_hemi_right	Time	0.946	2.122	2	0.346	0.948	1.000	0.500
alpha_region_front	Time	0.993	2.278	2	0.870	0.993	1.000	0.500
alpha_region_central	Time	0.793	8.819	2	0.012	0.828	0.883	0.500

Table 29

Tests of within-subject effects

Source	Item	Type Ⅲ sum of squares	df	Mean square	*F*	Sig.
time	alpha_hemi_left	0.000	2	5.988	18.298	0.000
	alpha_hemi_right	5.349	2	2.674	5.878	0.004
	alpha_region_front	5.559	2	2.779	11.128	0.000
	alpha_region_central	5.542	2	2.771	6.703	0.002
time * group	alpha_hemi_left	4.472	2	2.236	6.832	0.002
	alpha_hemi_right	4.701	2	2.351	5.167	0.008
	alpha_region_front	5.717	2	2.859	11.444	0.000
	alpha_region_central	4.879	2	2.439	5.902	0.004
Error (time)	alpha_hemi_left	0.000	78	3.272		
	alpha_hemi_right	0.000	78	4.549		
	alpha_region_front	0.000	78	2.498		
	alpha_region_central	0.000	78	4.133		

The results of the between-subject test revealed that, in addition to the group factor P value observed for the power of the alpha_hemi_right waveband (< .05), those observed for the power of the other alpha wavebands exhibited > .05, illustrating that the effect of group factor was nonsignificant. Except for those of the alpha_hemi_right waveband, the alpha-wave power values in all brain areas were similar between the two groups, as shown in Table 30.

Table 30

Tests of between-subject effects

Source	Item	Type Ⅲ sum of squares	df	Mean square	F	Sig.
Intercept	alpha_hemi_left	0.005	1	0.005	338.903	0.000
	alpha_hemi_right	0.005	1	0.005	545.632	0.000
	alpha_region_front	0.005	1	0.005	554.616	0.000
	alpha_region_central	0.005	1	0.005	407.922	0.000
Group	alpha_hemi_left	4.496	1	4.496	3.248	0.079
	alpha_hemi_right	4.199	1	4.199	4.336	0.044
	alpha_region_front	3.079	1	3.079	3.311	0.077
	alpha_region_central	4.218	1	4.218	3.244	0.079
Error	alpha_hemi_left	0.001	39	1.384		
	alpha_hemi_right	0.000	39	9.684		
	alpha_region_front	0.000	39	9.299		
	alpha_region_central	0.001	39	1.300		

Plot submenus were used to create run charts that presented the variation in the average indicator values measured three times. The run charts explicitly revealed the changes in the alpha-wave power values in all brain regions over time. Figures 12-15 show that the data collected from the training group varied prominently over time.

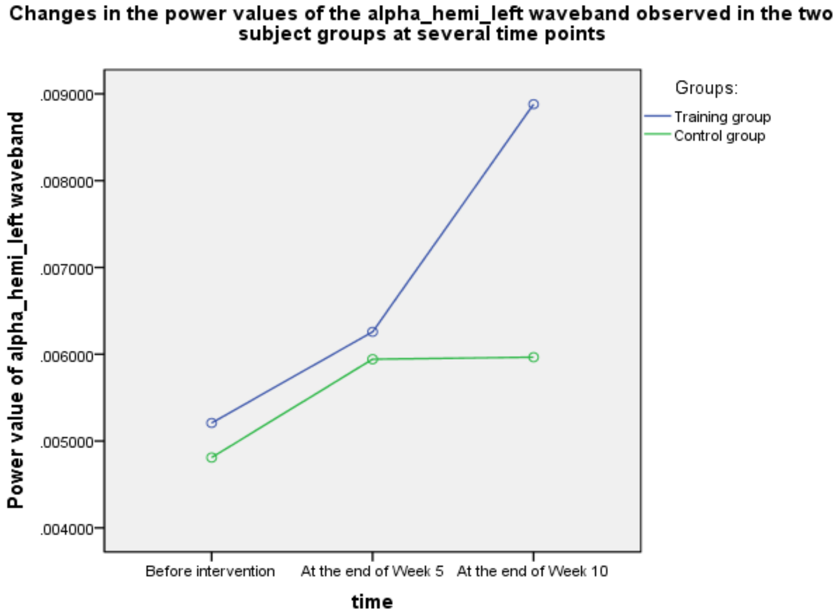


Figure12. Changes in the power values of the alpha_hemi_left waveband observed in the two subject groups at several time points

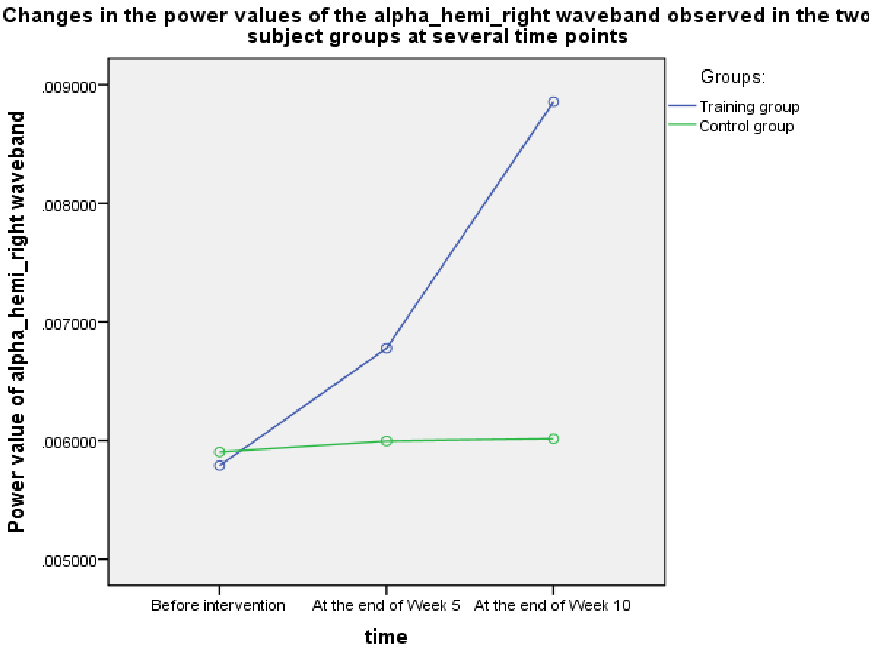


Figure 13. Changes in the power values of the alpha_hemi_right waveband observed in the two subject groups at several time points.

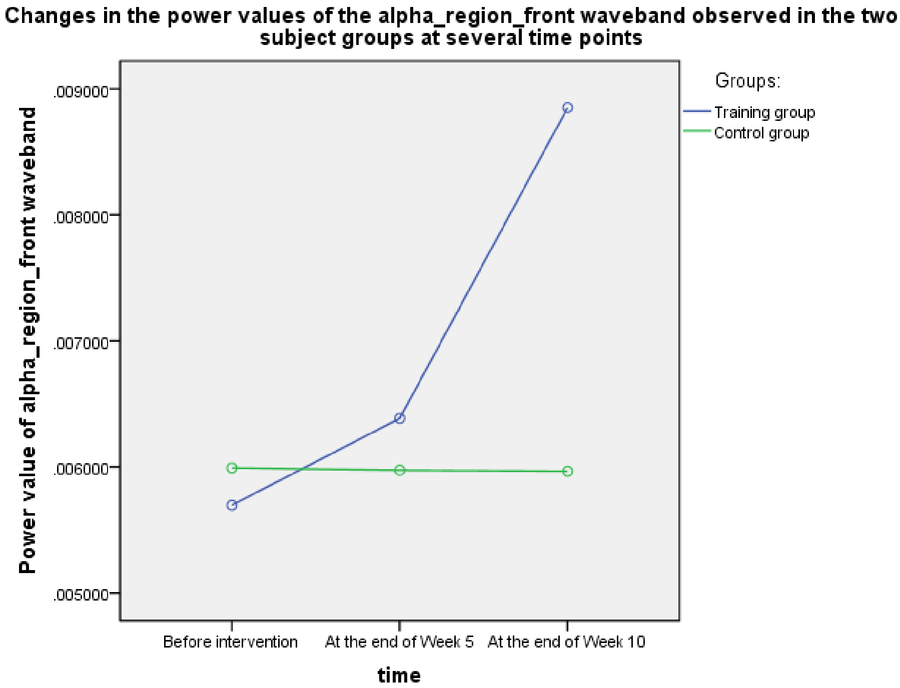


Figure 14. Changes in the power values of the alpha_region_front waveband observed in the two subject groups at several time points.

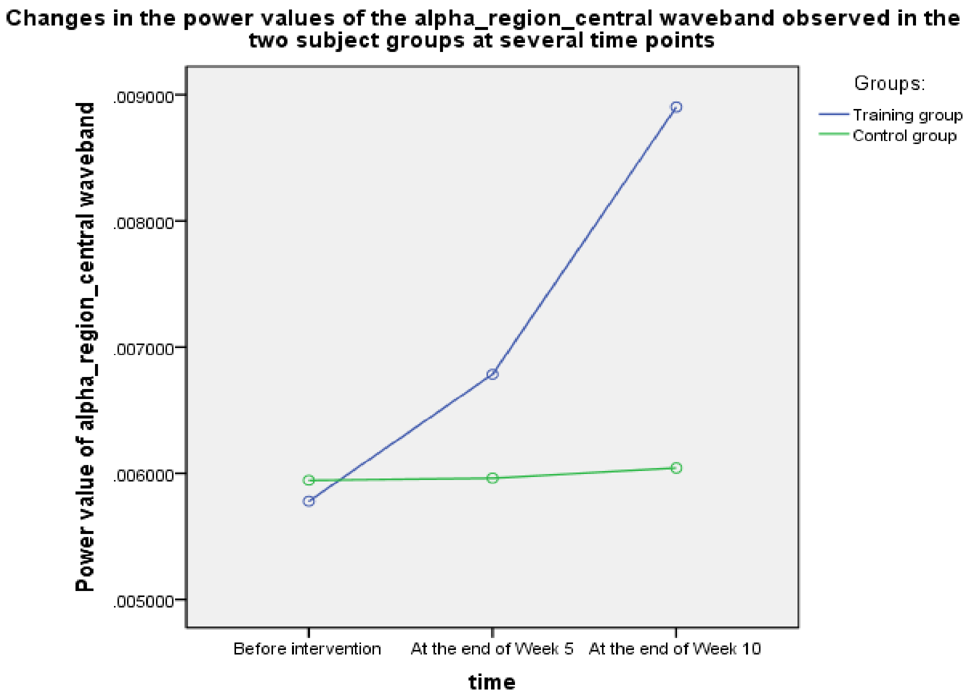


Figure 15. Changes in the power values of the alpha_region_central waveband observed in the two subject groups at several time points.

Between-subject pairwise comparison of the alpha-wave power values in all brain areas.

Before the intervention, the alpha-wave power values in all brain areas of the two subject groups differed nonsignificantly (all P > .05). At the end of Week 5, compared with the control group, the limb-exercise training group did not exhibit significantly increased alpha-wave power values in all brain areas (all P > .05). At the end of Week 10, the limb-exercise training group exhibited significantly increased alpha-wave power values in all brain areas (P < .01). The results indicated that, for MCI patients, limb-exercise training significantly increased their alpha-wave power values in all brain areas (Table 31).

Within-subject pairwise comparison of the alpha-wave power values in all brain areas

Table 32 compares the alpha-wave power values in all brain areas of subjects within the same group at different time points. LSD was employed to compare the conditions of the subjects at three periods: from before the intervention (S_0) to the end of Week 5 (S_1); from before the intervention (S_0) to the end of Week 10 (S_2); and from the end of Week 5 (S_1) to the end of Week 10 (S_2). The results revealed that, although the alpha-wave power values in all brain areas of the subjects in the training group from S_0 to S_2 differed no significantly (all $P > .05$), the alpha-wave power values in all brain areas of the other measured periods differed significantly (all $P < .05$). Furthermore, the alpha-wave power values measured at the end of Week 10 was significantly higher than those measured at the end of Week 5 ($P_L = 0.002$, $P_R = 0.007$, $P_F = 0.000$, and $P_C = 0.023$). By comparison, the control group exhibited no statistically significant differences in the alpha-wave power values in all brain areas obtained at different periods (all $P > .05$). The results indicated that limb-exercise training exerted a positive effect on the brain function of MCI patients, in addition to increasing the alpha-wave power values in all brain areas of the training group subjects.

Table 31

Between-subject pairwise comparison of the alpha-wave power values in all brain areas.

Group	Category	Measurement times		
		Baseline	Week 5	Week 10
Training group	alpha_hemi_left	0.0052 ±0.0011	0.0062 ±0.0029	0.0088 ±0.0029
	alpha_hemi_right	0.0057 ±0.0022	0.0067 ±0.0019	0.0088 ±0.0028
	alpha_region_front	0.0056 ±0.0014	0.0064 ±0.0019	0.0088 ±0.0022
	alpha_region_central	0.0057 ±0.0021	0.0067 ±0.0029	0.0089 ±0.0034
Control group	alpha_hemi_left	0.0048 ±0.0016	0.0059 ±0.0032	0.0059 ±0.0029
	alpha_hemi_right	0.0059 ±0.0021	0.0059 ±0.0032	0.0060 ±0.0028
	alpha_region_front	0.0059 ±0.0022	0.0060 ±0.0029	0.0060 ±0.0019
	alpha_region_central	0.0059 ±0.0016	0.0060 ±0.0026	0.0060 ±0.0029
t	alpha_hemi_left	0.888	0.325	3.170
	alpha_hemi_right	-0.167	0.923	3.539
	alpha_region_front	-0.504	0.518	4.449

	alpha_region_central	-0.279	0.938	2.930
p	alpha_hemi_left	0.380	0.747	0.003
	alpha_hemi_right	0.868	0.362	0.001
	alpha_region_front	0.617	0.607	0.000
	alpha_region_central	0.781	0.354	0.006

Table 32

Within-subject pairwise comparison of the alpha-wave power values in all brain areas

Category	Group	Time point	$\overline{X} \pm S$	S_0–S_1 Mean difference	S_0–S_1 *P*	S_0–S_2 Mean difference	S_0–S_2 *P*	S_1–S_2 Mean difference	S_1–S_2 *P*
alpha_hemi_left	Training group	S_0	0.0052±0.0011	-0.0011	0.192	-0.0037	0.000	-0.0026	0.002
		S_1	0.0062±0.0029						
		S_2	0.0088±0.0029						
	Control group	S_0	0.0048±0.0016	-0.0011	0.178	-0.0012	0.169	-0.0000	0.978
		S_1	0.0059±0.0032						

		S_2	0.0059 ± 0.0029						
alpha_hemi_right	Training group	S_0	0.0057 ± 0.0022	-0.0010	0.189	-0.0031	0.000	-0.0021	0.007
		S_1	0.0067 ± 0.0019						
		S_2	0.0088 ± 0.0028						
	Control group	S_0	0.0059 ± 0.0021	-0.0001	0.910	-0.0001	0.891	-0.0000	0.981
		S_1	0.0059 ± 0.0032						
		S_2	0.0060 ± 0.0028						
alpha_region_front	Training group	S_0	0.0056 ± 0.0014	-0.0007	0.254	-0.0032	0.000	-0.0025	0.000
		S_1	0.0064 ± 0.0019						
		S_2	0.0088 ± 0.0022						
	Control group	S_0	0.0059 ± 0.0022	0.0000	0.981	0.0000	0.972	0.0000	0.991
		S_1	0.0060 ± 0.0029						
		S_2	0.0060 ± 0.0019						
alpha_region_central	Training group	S_0	0.0057 ± 0.0021	-0.0010	0.271	-0.0031	0.001	-0.0021	0.023

		S_1	0.0067±0.0029						
		S_2	0.0089±0.0034						
	Control group	S_0	0.0059±0.0016	-0.0000	0.982	-0.0001	0.899	-0.0001	0.917
		S_1	0.0060±0.0026						
		S_2	0.0060±0.0029						

Comparing the pre- and postintervention total scores of the beta-wave power in all brain areas of both subject groups

Analysing the effects of and interaction between time and grouping

The study used Mauchly's test of sphericity to determine whether the repeated data measurements were correlated. Except for the test result of the beta_hemi_ right waveband ($P > .05$), the test results were all $P < .05$, indicating a correlation among the data collected through the 3 repeated measurements. After the epsilon values of the 3 indicators (ie, beta_hemi_left, beta_region_friont, and beta _region_central wavebands) were corrected by applying the Greenhouse-Geisser procedure, the epsilon coefficients were all >0.7, indicating that repeated measures ANOVA can be conducted. The Mauchly's test of sphericity results are shown in Table 33.

The statistical results of the within-subject tests revealed that the time factor was statistically significant ($P < .01$) and that the measured results of the indicators (ie, beta-wave power values in all brain areas) changed over time. In addition, the interaction between time and grouping (time × grouping) was statistically significant ($P < .01$), which suggested that the effect of time factors on the subjects differed between the two groups. In other words, the effects of measurement time on the beta-wave power values in all brain areas differed between the two groups (Table 34).

The results of the within-subject test revealed that, the group factor P value for beta-wave power values in all brain areas was < .05, illustrating that grouping factor exerted a significant effect and that the beta-wave power values of the two subject groups varied, as shown in Table 35.

Plot submenus were used to create run charts that presented the variation in the average indicator values measured three times. Examining the run charts showed changes in the beta-wave power values over time. Figures 16-19 show that the data collected from the training group varied substantially over time.

Table 33

Mauchly's test of sphericity

Item	Within subject effect	Mauchly' W	Approx. Chi Square	df	Sig.	Epsilon		
						Greenhouse-Geisser	Huynh-Feldt	Lower bound
beta_hemi_left	Time	0.755	10.693	2	0.005	0.803	0.854	0.500
beta _hemi_right	Time	0.858	5.807	2	0.055	0.876	0.937	0.500
beta _region_front	Time	0.793	8.812	2	0.012	0.829	0.883	0.500
beta _region_central	Time	0.795	8.726	2	0.013	0.830	0.884	0.500

Table 34

Tests of within-subject effects

Source	Item	Type Ⅲ sum of squares	df	Mean square	*F*	Sig.
time	beta_hemi_left	0.002	2	0.001	101.678	0.000
	beta _hemi_right	0.002	2	0.001	110.544	0.000
	beta _region_front	0.002	2	0.001	115.219	0.000
	beta _region_central	0.003	2	0.001	80.461	0.000
time * group	beta_hemi_left	0.000	2	0.000	15.756	0.000
	beta _hemi_right	0.000	2	0.000	21.583	0.000
	beta _region_front	0.000	2	0.000	18.629	0.000
	beta _region_central	0.001	2	0.000	15.902	0.000
Error (time)	beta_hemi_left	0.001	78	9.703		
	beta _hemi_right	0.001	78	9.800		
	beta _region_front	0.001	78	8.012		
	beta _region_central	0.001	78	1.596		

Table 35

Tests of between-subject effects

Source	Item	Type Ⅲ sum of squares	df	Mean square	F	Sig.
Intercept	beta_hemi_left	0.021	1	0.021	2108.798	0.000
	beta _hemi_right	0.021	1	0.021	3232.689	0.000
	beta _region_front	0.018	1	0.018	2909.322	0.000
	beta _region_central	0.027	1	0.027	2177.355	0.000
Group	beta_hemi_left	0.000	1	0.000	44.014	0.000
	beta _hemi_right	0.000	1	0.000	65.248	0.000
	beta _region_front	0.000	1	0.000	57.510	0.000
	beta _region_central	0.001	1	0.001	47.457	0.000
Error	beta_hemi_left	0.000	39	9.916		
	beta_hemi_right	0.000	39	6.617		
	beta_region_front	0.000	39	6.312		
	beta_region_central	0.000	39	1.254		

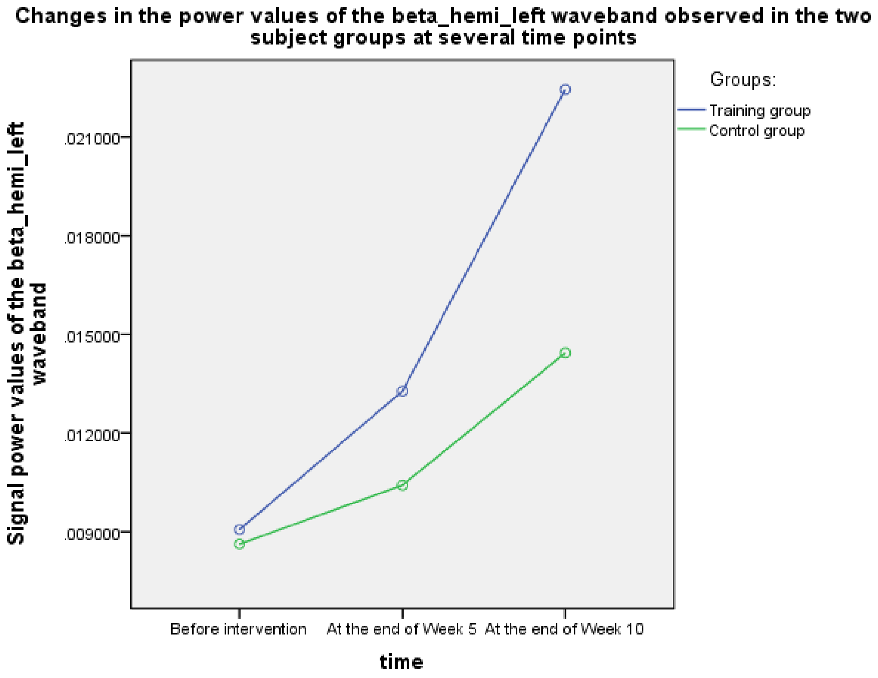


Figure 16. Changes in the power values of the beta_hemi_left waveband observed in the two subject groups at several time points.

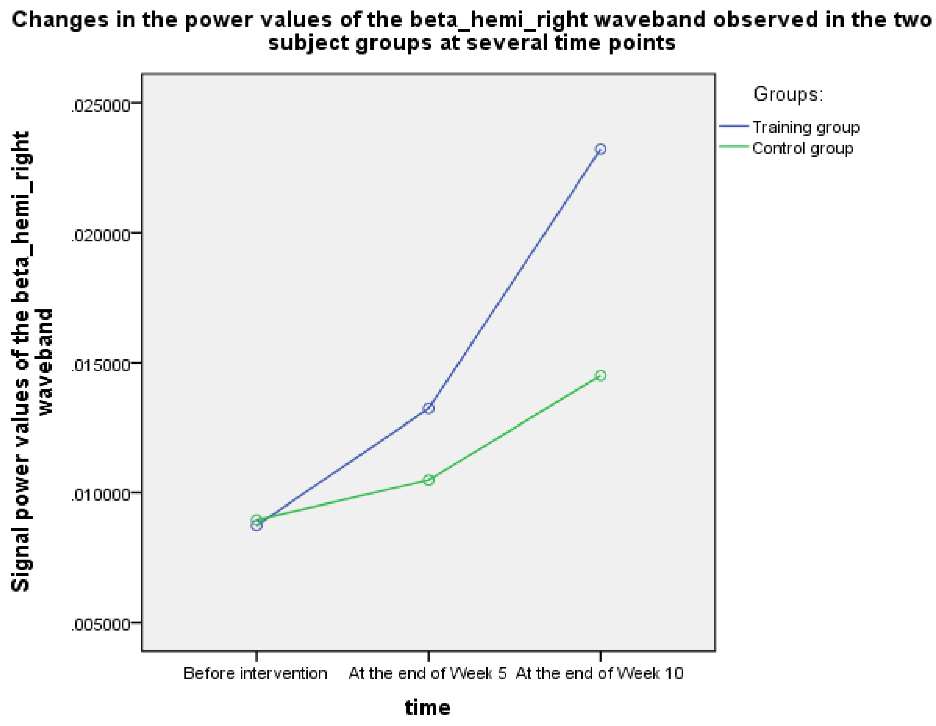


Figure 17. Changes in the power values of the beta_hemi_right waveband observed in the two subject groups at several time points.

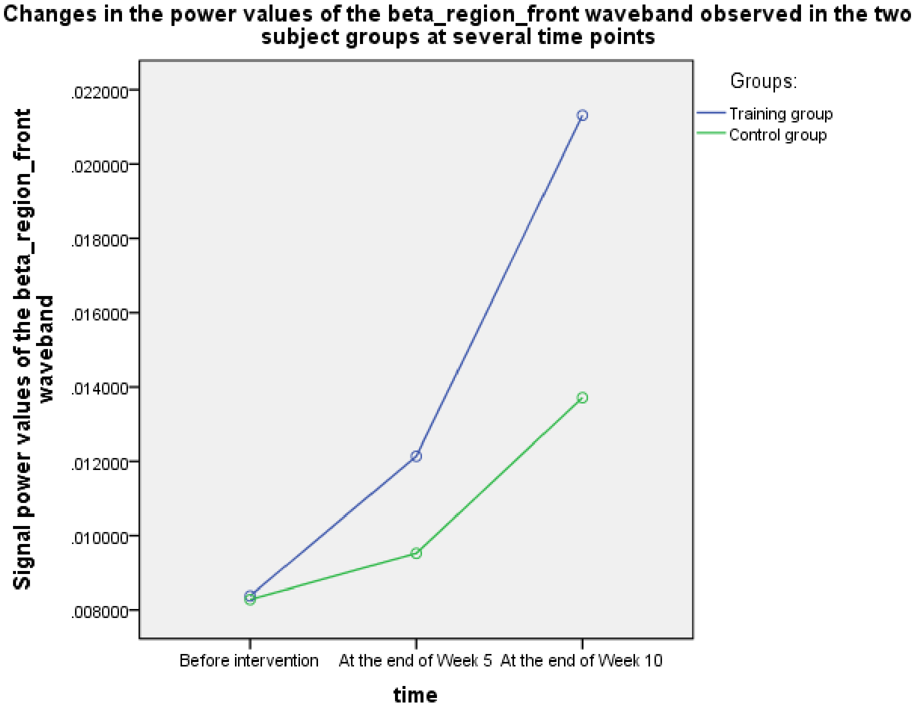


Figure 18. Changes in the power values of the beta_region_front waveband observed in the two subject groups at several time points.

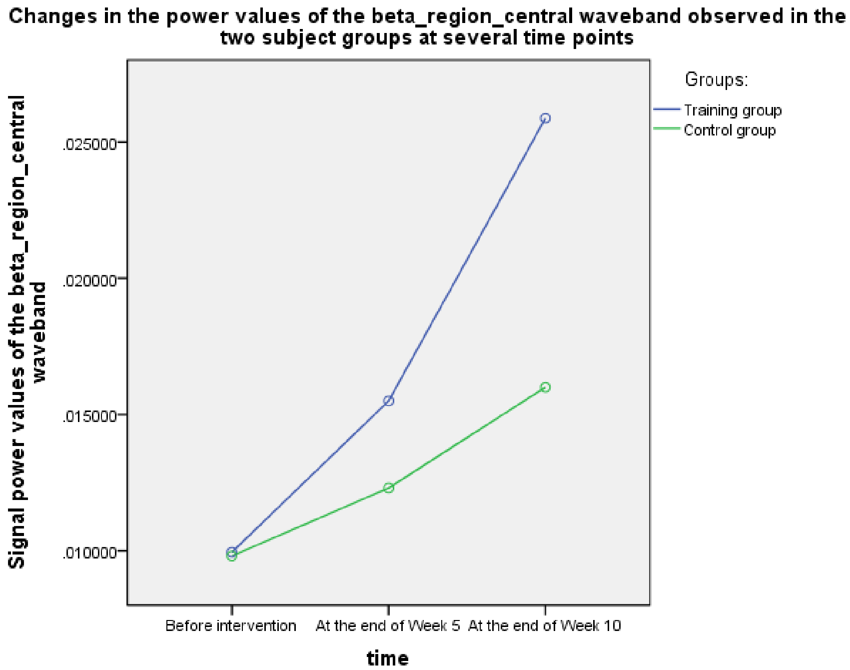


Figure 19. Changes in the power values of the beta_region_central waveband observed in the two subject groups at several time points.

Comparing the beta-wave power values in all brain areas of both groups

Before the intervention, the beta-wave power values in all brain areas of the two subject groups differed no significantly (all $P > .05$). At the end of Week 5, compared with the control group, the training group exhibited significantly increased beta-wave power values in all brain areas (all $P > .05$). At the end of Week 10, the results of t tests showed that the training group measured significantly higher beta-wave power values in all brain areas than those measured at the end of Week 5 ($P < .01$). The results indicated that, for MCI patients, limb-exercise training significantly increased their beta-wave power values in all brain areas (Table 36).

Within-subject pairwise comparison of the beta-wave power values in all brain areas

Table 37 compares the beta-wave power values in all brain areas of subjects within the same group, at different time points. LSD was employed to compare the subjects at three periods: from before the intervention (S_0) to the end of Week 5 (S_1); from before intervention (S_0) to the end of Week 10 (S_2); and from the end of Week 5 (S_1) to the end of Week 10 (S_2). The results revealed that, in the training group, the beta-wave power values in all brain areas for all three periods differed significantly (all $P < .01$). Furthermore, the variations in the beta-wave power values of the training group at the end of Week 5 were more significant than were those measured at other time points. By comparison, except for the alpha_region_central waveband, subjects in the control group exhibited no statistically significant differences in the beta-wave power values in all brain areas during the S_0–S_1 period (all $P > .05$). Regarding S_0–S_2 and S_1–S_2, the beta-wave power values of the subjects in the control group differed significantly (all $P < .01$). This comparison revealed that limb-exercise training exerted a positive effect on the brain function of MCI patients, in addition to increasing the beta-wave power values in all brain areas of the training group subjects.

Table 36

Comparing the beta-wave power values in all brain areas of both groups

Group	Category	Measurement times		
		Baseline	Week 5	Week 10
Training group	beta_hemi_left	0.0091 ±0.0017	0.0133 ±0.0021	0.0224 ±0.0048
	beta_hemi_right	0.0087 ±0.0027	0.0132 ±0.0022	0.0232 ±0.0039
	beta_region_front	0.0084 ±0.0016	0.0121 ±0.0021	0.0213 ±0.0044
	beta_region_central	0.0099 ±0.0035	0.0155 ±0.0028	0.0259 ±0.0057
Control group	beta_hemi_left	0.0086 ±0.0023	0.0104 ±0.0026	0.0144 ±0.0041
	beta_hemi_right	0.0089 ±0.0023	0.0105 ±0.0016	0.0145 ±0.0040
	beta_region_front	0.0083 ±0.0021	0.0095 ±0.0019	0.0137 ±0.0032
	beta_region_central	0.0098 ±0.0031	0.0123 ±0.0027	0.0160 ±0.0043
t	beta_hemi_left	0.712	3.920	5.737
	beta_hemi_right	-0.276	4.535	6.966
	beta_region_front	0.169	4.164	6.307

	beta_region_central	0.133	3.681	6.228
p	beta_hemi_left	0.480	0.000	0.000
	beta_hemi_right	0.784	0.000	0.000
	beta_region_front	0.867	0.000	0.000
	beta_region_central	0.895	0.001	0.000

Table 37

Within-subject pairwise comparison of the beta-wave power values in all brain areas

Category	Group	Time point	$\overline{X}$ ±S	$S_0 \sim S_1$		$S_0 \sim S_2$		$S_1 \sim S_2$	
				Mean difference	*P*	Mean difference	*P*	Mean difference	*P*
beta_hemi_left	Training group	S_0	0.0091±0.0017	-0.0042	0.000	-0.0134	0.000	-0.0092	0.000
		S_1	0.0133±0.0021						
		S_2	0.0224±0.0048						
	Control group	S_0	0.0086±0.0023	-0.0018	0.063	-0.0058	0.000	-0.0040	0.000
		S_1	0.0104±0.0026						
		S_2	0.0144±0.0041						
beta_hemi_right	Training group	S_0	0.0087±0.0027	-0.0045	0.000	-0.0145	0.000	-0.0099	0.000
		S_1	0.0132±0.0022						

		S_2	0.0232±0.0039						
	Control group	S_0	0.0089±0.0023	-0.0015	0.088	-0.0056	0.000	-0.0040	0.000
		S_1	0.0105±0.0016						
		S_2	0.0145±0.0040						
beta_region_front	Training group	S_0	0.0084±0.0016	-0.0038	0.000	-0.129	0.000	-0.0092	0.000
		S_1	0.0121±0.0021						
		S_2	0.0213±0.0044						
	Control group	S_0	0.0083±0.0021	-0.0012	0.112	-0.0054	0.000	-0.0042	0.000
		S_1	0.0095±0.0019						
		S_2	0.0137±0.0032						
beta_region_central	Training group	S_0	0.0099±0.0035	-0.0056	0.000	-0.0159	0.000	-0.0104	0.000
		S_1	0.0155±0.0028						
		S_2	0.0259±0.0057						
	Control group	S_0	0.0098±0.0031	-0.0025	0.023	-0.0062	0.000	-0.0037	0.001
		S_1	0.0123±0.0027						
		S_2	0.0160±0.0043						

Chapter 5

DISCUSSION OF THE FINDINGS AND RECOMMENDATIONS

5.1 Correlation between the PS and cognitive function of the MCI patients.

5.1.1 Psychomotor speed of MCI patients

Cognitive function measurement indicates neuropsychiatric status. A person's neuropsychiatric condition can be aptly detected from items such as fast memory, attention, psychomotor speed, language learning, and motion flexibility. Among these items, psychomotor speed is a subclinical health care indicator for identifying early neurological damage because it is easy to measure and exhibits high sensitivity and reliability. Psychomotor speed has been included in the Neurobehavioral Core Test Battery by the World Health Organisation, and has been widely applied (Bowler et al., 2001). Early studies on psychomotor speed have focused mainly on researching Alzheimer's disease (AD). Such studies have found that when the reaction time of patients with AD declines, the phenomenon indicates an early stage of non-aging-induced slow response or slowness. Such patients exhibit a decline in cognitive speed and their capacity to react to stimuli. In addition, a decrease in the reaction rate of AD patients in correct responses indicates onset of impaired cognitive function. Longer-than-normal reaction times in correct responses serve as an indicator for diagnosing AD (Uh et al., 2010). These findings show that measuring psychomotor speed can also indirectly indicate a person's cognition level.

The present study adopted the FTT and PPT to measure the psychomotor speed of MCI patients. The results show that the mean frequency of finger taps among the MCI patients was 45.00 ± 5.43 for the left hand and 48.39 ± 4.86 for the right hand. The average for healthy people in China aged ≥45 years is 37 times per 10 seconds (Gong, 1986). Thus, the psychomotor speed of MCI patients is far slower than that of healthy adults. Regarding the PPT, the subjects in the present study correctly inserted on average 12.27 ± 1.80 pegs with their left hand, 13.22 ± 1.93 with their right hand, and 10.75 ± 1.51 with both hands. In a study analysing the value of PPT in diagnosing

AD, Sun et al. (Sun et al, 2012) reported relatively similar PPT results in healthy older adults. However, in that study, they did not test the cognitive function of healthy elderly adults. Consequently, standard normative data of the PPT results remain lacking among studies conducted in China. Consequently, the PPT results obtained from the subjects in the present study are yet to be compared with those of healthy elderly adults with normal cognitive function.

5.1.2 Cognitive functions of MCI patients

Elderly adults exhibit varying degrees of decline in cognitive function with age. Such decline can further develop into MCI or even AD (Li, 2011; Simon, 2012). The results of this study show that elderly adults with MCI exhibit a functional decline in varying degrees of visuospatial execution, naming, attention, language, abstraction, delayed recall, and orientation. Among these functions, delayed recall is the most severe (mean: 2.41 $\pm$0.92).

Categorised as recent memory, delayed recall is mainly examined according to a person's long-term recall ability, which belongs to episodic memory, with the retention ability of short-term memory after learning. Delayed recall requires a precise coding of and searching for vocabulary in memory. Structural magnetic resonance imaging (MRI) of the brain reveals that the degree of atrophy in the entorhinal and hippocampal cortex of elderly adults with MCI are in between that observed in elderly adults with ordinary cognitive functions and that of patients with AD (Li et al, 2010). This phenomenon is possibly the mechanism that leads to the observable decline in delayed recall in elderly patients with MCI. Lehrner et al. (Lehrner et al, 2005) considered that among the numerous neuropsychological tests, delayed recall—specifically, damage to short-term memory for storing textual information—is the most sensitive indicator indicating that MCI is progressing to AD. Therefore, testing for delayed recall ability has crucial implications in identifying a decline in cognitive function.

The MoCA scale uses a cross-connection test, copying a cube, and drawing a clock to examine the degree of visuospatial and executive function. The results of the present study reveal a relatively obvious decline in visuospatial and executive function. This finding accords with that of previous studies (Gao et. al., 2011; Pendlebury et al., 2012). Functional MRI of brain activity was applied to examine the visuospatial and executive function of MCI patients. Compared with elderly adults with normal cognitive function, those with MCI exhibited significantly lower function and a smaller range of activation in the bilateral parietal, occipitotemporal junction, and visual cortex. The neural network activation observed in MCI patients was weaker than that seen in people with normal cognitive function. Consequently, the visuospatial function of MCI patients declined (Bai et al, 2003). Executive function is a cognitive neural mechanism that is activated when a person attempts to achieve a specific objective, and the mechanism involves coordinating multiple cognitive processes through flexible optimisation. The frontal, particularly the prefrontal, is considered the centre responsible for executive function. A decline in executive function in elderly adults with MCI might be attributable to subcortical lesions damaging the frontal subcortical loops, which are related to executive function. Furthermore, previous research revealed that damage to the white matter between the frontal and other brain areas is related to a decline in executive function in MCI patients (Fennema et al., 2009). The present study revealed that older patients with MCI have anomia. The result can be related to decreased visual acuity and blurred vision. In addition, in the MoCA-BJ, the statement testing language repeat function is long and difficult to pronounce, and a difference in language aspects between the test administer and the subjects renders the answer susceptible to be penalized based on subjective lingual perceptions. Consequently, the subjects were likely to lose points for this item. Most of the MCI patients exhibited normal ability in place orientation; they were only unsure of the day of the week, and such confusion might be explained by the elderly adults being retired and being unconcerned about which day of the week it was when responding to that item. This result accords with the findings of a previous study (Matsuda & Saito, 2009). In summary, the results of the present study suggest that the MCI patients exhibited damage to multiple cognitive domains, but the damage level in these domains was not equal. Among all domains, damage to delayed recall and visuospatial and executive function exhibited was more severe and prevalent. Understanding the characteristics of cognitive impairment in elderly adults with MCI enables community-dwelling MCI patients to be identified, their condition diagnosed, and then referred for early-stage intervention.

5.1.3 Correlation between the PS and Cognitive Function in MCI Patients.

The results of this study show that the scores obtained in all dimensions of the FTT and PPT were significantly correlated to those acquired in all dimensions of the MoCA total score (all $P < 0.05$). Furthermore, the scores for all dimensions of the FTT were also significantly correlated to that for PPT (all $P < 0.05$). These results confirm that psychomotor speed is a valid indicator in assessing cognitive function, and that psychomotor speed can be adopted in preliminary screening of MCI patients. The FTT mainly evaluates finger movement speed and reflects coordination and the accuracy of movement, both of which are cognitive functions to a certain extent (Nutt et al., 2000). In addition, the PPT indicates the flexibility and movement speed of the hands as well as the level of hand–eye coordination (Desrosiers et al, 1995). A previous study conducted both the PPT and FTT on patients with Parkinson's disease, reporting that the PPT scores directly reflected the patients' movement conditions and were highly related to ADLs and movement-related scores; by comparison, the FTT is highly correlated with parts of ADLs and is mainly influenced by a patient's cognitive and psychomotor condition (Müller et al, 2000). Both the FTT and PPT are categorised as quantitative motor measures (QMM), which test psychomotor function through quantitative examination and evaluation by using simple instruments or equipment. This type of test is a relatively objective measure in testing psychomotor function; moreover, the results are unaffected by test administers but can facilitate identifying subtle changes in psychomotor function (Brewer et al., 2009). Several studies in recent years have indicated that QMMs exhibit predictive value in screening Parkinson's disease and schizophrenia (Daneault et al, 2013; Bracht et al, 2012). The present study confirms the correlation between QMM and cognition level. The results may serve as a basis for analysing the predictive value of psychomotor speed to MCI. Therefore, understanding psychomotor speed characteristics of elderly adults with MCI enables early identification of MCI patients and early disease intervention.

5.2 Influences of Limb Exercise Training on the PS of MCI Patients.

This study adopted the FTT and PTT to evaluate the psychomotor speed of the 2 subjects groups at baseline, Week 5, and Week 10 of the intervention. The results showed that at Week 10, the scores in the 2 dimensions of the FTT and 3 dimensions of the PPT obtained by the limb exercise training intervention group were higher than those obtained at baseline. However, from baseline to Week 10, the control group exhibited a smaller extent of improvement in the same scores. Furthermore, the FTT and PPT scores at Week 10 were significantly higher than those measured at Week 5 (all $P < 0.05$). By comparison, the control group exhibited a nonsignificant improvement in FTT and PPT scores throughout the same period. These results indicate that the limb exercise training intervention positively influenced the psychomotor speed of the MCI patients.

In the limb exercise training project, the PPT and ball-holding exercises mainly involved training the fine motor control abilities of the hands. These abilities refer to a person's capacity to complete a specific task mainly through the movements of minor muscles in the hands and fingers in coordination with psychological activity (e.g., perception and attention). Fine motor abilities involve muscle strength in controlling fine movements as well as flexibility and accuracy in performing such movements (Morishita et al., 2011). Performing fine movements with the hands first involves visual feedback. Signals are transmitted to brain centre, which interprets the signals and then transmits them to the hand muscles through nerve conduction to control muscle contraction for task performance. This process activates cognitive function. Previous studies on the central motor-regulating organs such as the cerebellum and striatal have revealed that the organs involved in fine movements typically possess cognitive function. The cerebellum has been considered a control centre for regulating fine movements. However, a growing body of recent evidence has confirmed that the cerebellum is also involved in nonmotor functions, such as feeling and cognition, and no motor behaviours such as time determination, perception–space determination, and language expression. In addition, the cerebellum plays a crucial role in abstraction and complex problem solving (Sgambato et al., 2003). The cerebellum is widely connected to the central nervous system and involves multiple neural activities in its function. The results strongly suggest that when the cerebellum is activated in performing fine movements, feelings and cognitive functions in the cerebellum are also activated, thus enabling cognitive development (Colombo et al., 2003).

Fine motor control ability of the hands in elderly adults can be improved through training. Previous studies examining various areas of the cerebral cortex have revealed that motor skill acquisition is closely related to changes in synaptic plasticity (Hodgson & Standish, 2005). Kim et al (2010) investigated the influences of hand activities, such as clapping, forming and releasing a fist, and consecutive finger reversal with both hands, on activation of the cerebral cortex. MRI images of 14 older adults with normal cognitive function revealed changes in the prefrontal cortex, motion system, and premotor areas. The results revealed that clapping exerted the maximal influence on the whole function area of the brain. Specifically, clapping caused the maximal change in the motion system and premotor areas, whereas consecutive finger reversal with both hands caused the maximal change in the prefrontal area. Cognitive function is closely related to activities in these brain areas.

After identifying the fine motor abilities of MCI patients, targeted fine-motor training tasks should be designed. Through examining statistical feedback from the FTT, the present study aided the subjects through training their fine motor control abilities specifically related to their hands. The intervention had a profound effect in preventing and mitigating the decline in their fine motor ability of the hands and cognitive function exhibited by MCI patients.

5.3 Influence of the Limb Exercise Training Intervention on the Cognition Level of the MCI patients.

The results of this study show that after 10 weeks of limb exercise intervention, the total score of MoCA obtained by the MCI patients in the training intervention group was improved by 5.85 points. Moreover, the improvement was statistically significant compared with that of the control group (t = 4.614; P = 0.000). Consequently, this study confirms that limb exercise training intervention improves the cognitive function of MCI patients. The results accord with those of several previous studies (Snigdha et al, 2014; Garcia et al, 2013). An analysis of related studies on exercise intervention aimed at improving cognitive function revealed that multiple methods can be adopted for training and that the measures of intervention vary. The present study referenced the structured limb exercise intervention proposed by foreign scholars, integrated Chinese cultural customs and the conditions of MCI patients in communities and a nursing home in China into the intervention measure and followed the guidance of rehabilitation physicians as well as kinematics and nursing experts in developing a limb exercise training intervention program according to the needs of elderly adults residing in Chinese communities. The program covers 5 exercise methods.

5.3.1 Aerobic Exercise

Aerobic exercise includes full shoulder-joint, muscle-stretching, and ball-holding exercises. Ranging from basic to advanced movements, these exercises correspond to the learning and memory capacity of elderly adults and are easy to learn. Because community-dwelling MCI patients are interested in these exercises, they tend to persist in performing these exercises. A study by Angevaren et al. found that aerobic exercises improve cognitive speed, short-term memory, and visual and audio attention of elderly adults (Angevaren et al, 2008). All aerobic exercises involved in this study are of moderate intensity, which was confirmed to be effective in improving the cognitive function of elderly adults (Baker et al., 2010).

5.3.2 Strength Training

Strength training involves movements that counter the resistance of one's own body rhythm, such as throwing sandbags and performing step exercises. Strength exercises are physical exercises that involve using muscles to counter resistance. A previous study involving random group experiment revealed that participating in resistance exercises significantly enhances the cognitive function of elderly adults (Kimura et al., 2010). Fallah et al (2013) conducted a 1-year resistance training program for community-dwelling elderly women and found that the selective attention capacity of the research subjects improved. In the 2012 Alzheimer's Association International Conference in the United States, researchers from Canada and the United States proposed that resistance training facilitates improving the cognitive function and functional plasticity of elderly women, particularly the executive cognitive functions of selective attention, conflict resolution, and the associated memory capacity. Such outcomes are likely related to resistance training causing functional changes in 3 areas of the cerebral cortex that are related to coding, nonverbal coding, and nonverbal memory (i.e., the right lingual gyrus, occipital fusiform gyrus, and frontal pole).

5.3.3 Balance Training

Balance training includes side-stretch and hopscotch exercises. Side-stretch exercises mainly train the static balance ability of MCI patients, and hopscotch exercises mainly train the dynamic balance ability of MCI patients. Dornery et al. trained the strength and balance ability of community-dwelling elderly adults aged ≥75 years (Dorner et al., 2007) and found their MMSE scores increased from 20.9 to 23.9. This result was a significant improvement compared with the control group in that study. Therefore, strength and balance training are considered effective for improving the cognitive function of elderly adults. Nagamatsu et al (2013) conducted a comprehensive study on the influence of balance ability on specific areas of cognitive function. The results showed that the spatial memory of elderly adults with MCI was improved after completing 6 months of balance training. Thus, balance training can improve spatial memory.

5.3.4 Coordination Training

Coordination training includes sandbag throwing, ball-holding exercises, hopscotch exercises, and step exercises. When the researchers explained the processes of these exercises, the research subjects exhibited a considerable level of interest in these items. Coordination training requires the functioning muscles of the body to perform actions with correct timing, movement direction and speed, and to exhibit stable balance and rhythm. Among all types of physical training exercises, coordination training is the most difficult because it requires cognitive function as well as motor rhythm. Previous studies have shown that physical and psychological exercises that integrated cognitive engagement and coordination training (such as tai chi) can maintain and even slow the process of cognitive function decline of elderly adults (Lam et al, 2012). A study by Voelcker et al (2011) also confirmed that coordination training can improve the executive function and perceptual speed of elderly adults. Through using functional MRI measurements, Claudia et al. revealed that compared with aerobatic training, which activates the neural networks through increasing the intensity of perceptual exercises, coordination training improved the signal-processing speed by activating the visuospatial neural network.

5.3.5 Sensitivity Training

Sensitivity training includes a pegboard exercise and a ball-holding exercise. In the training process of the pegboard exercise, the research subjects were asked to insert pegs into a pegboard and then remove them sequentially. The process trained hand–eye coordination, enhanced individual finger flexibility, and improved attention and executive function. This study implemented the pegboard training exercise on the experimental group and it effectively enhanced the PPT scores of the training intervention group. According to the analysis results, the limb exercise training intervention was considered effective in enhancing the cognition level of the MCI patients.

5.4 Effect of Limb-Exercise Training on the EEG Activities of MCI Patients

The bioelectrical activities in the cerebral hemispheres are activated by cerebral cortical pyramidal cells and postsynaptic potentials and are regulated by nonspecific nuclei of the thalamus. Stimuli and feedback among the thalamus, brainstem reticular formation, and the cerebral cortex affect EEG activity rhythms (Jiang, 2004). Berger (1924) discovered that cerebral bioelectrical activities can be recorded from the scalp (www. epub. org). In the mid and late twentieth century, developments in science and technology, particularly the computer technology, have advanced EEG technology to one that is no longer confined to merely routine EEG testing. In 1956, Cooley and Tukey proposed FFT, a method that transforms EEG signals to digital spectrums of energy (or power) and frequency, thereby realizing the quantitative analysis of EEG diagrams (Jiang, 2004). EEGs of healthy adults mainly comprise alpha and beta waves, with alpha waves serving as the major frequency. The two brainwaves are distributed in different brain areas; alpha waves are mainly distributed in the occipital and parietal lobes, whereas beta waves are mainly located in the frontal and temporal lobes. Activities of alpha and beta waves are stable; when pathological changes occur in the brain, alpha and beta waves produce changes accordingly. Because MCI patients have a high risk of AD, understanding the EEG characteristics of MCI patients has critical and practical value for MCI prevention.

5.4.1 Typical Characteristics of EEG Diagrams for Older MCI Patients

EEG visual analysis is one of the most commonly applied methods in clinical settings for observing EEG changes in patients. A slowing of basic EEG rhythms generally indicates a decline in cerebral function. Specifically, a slowing of alpha wave rhythms is likely an early indicator that the cerebral physiological functions are beginning to deteriorate (Liang & Lu, 1994). Through a visual analysis of the EEG images of MCI patients, this study revealed that alpha wave patterns obtained from the MCI patients tended to exhibit slowed rhythms, decreased activity, and lower amplitudes and that decreased beta wave activities were observed in most of the MCI patients. These results correspond to those of Cantero et al (2009). Furthermore, a previous study revealed that beta wave frequencies in older adults increased and then decreased as they age, and attributed this phenomenon to the existence of a certain compensation mechanisms (Zheng, 2004). However, the effect of age on beta frequencies in MCI patients' remains to be discussed in future studies.

5.4.2 Effect of Limb-Exercise Training on the EEG Waveforms and Frequencies of MCI Patients.

This study adopted an Emotiv EPOC neuroheadset for assessing the variations in the power values of the alpha and beta waves obtained at several time points (ie, before the intervention and at the end of Weeks 5 and 10 of the intervention) in multiple brain areas of 2 groups of MCI patients. The results indicated that, at the end of Week 10, the training group registered higher alpha- and beta-wave power values than those measured before the intervention or than those of the control group (both $P < .01$). In the control group, the alpha- and beta-wave power values were higher at the end of Week 10 than they were before the intervention; these results were likely caused by the subjects in the control group voluntarily enhancing their physical training after being educated about MCI. Previous studies have analysed the relationship between alpha waves and the physical motions of exercise processes to determine the role of alpha waves in the motion control process (Babiloni). Therefore, in sports science, alpha waves are considered to indicate psychological attentiveness or state of readiness. However, the possible mechanisms underlying the effect of exercise on cerebral activity remain inconclusive. Vernon (2005) found that EEG neurobiological feedback improved alpha wave activities during exercise training and increased individual attentiveness, eliminating the effect of external stimuli and irrelevant thinking. Consequently, individual cognitive status was improved. In addition, exercises that required visual-spatial-motor control generated specific stimuli (such as visual stimuli), which changed the power of the alpha wave and enhanced exercise efficacy and cognitive function (DelPercio et al, 2007). The present study incorporated hopscotch exercise and pegboard training, which provided the subjects with visual stimuli and enhanced the subjects' spatial and motor control abilities, thereby indirectly increasing the subjects' cognitive levels. Beta waves are nonsynchronised, fast waves that exhibit high frequencies and low amplitudes. In brain treatment (hyperventilation) or intellectual activities, alpha waves generally transform into beta waves, which indicate a status of being alert and an intensely active cortical neurons. A hyperventilation experiment induces a temporary decrease in the partial pressure of the arterial carbon dioxide, thus enhancing the hypoxia tolerance of brain tissue and reducing brain tissue damage. Thus, hyperventilation experiments can be conducted to indirectly determine cerebral functional status (179. Wong & Chen, 1988). The regular limb-exercise training that was adopted in this study gradually enhanced the subjects' hypoxia tolerance and improved their cerebral functional reserves; therefore, this type of training positively influenced individual cognitive functions.

Past neuroimaging studies have developed several intuitive approaches for investigating the mechanisms underlying the effects of exercise on learning memory function. Studies on MfRI have reported that exercise training induces changes in the functional activation patterns of the brain. For instance, older adults who performed 6 months of exercise intervention (walking) displayed increased neural activation in the middle frontal gyrus and superior parietal lobe and inhibited activation in the front cingulate. These changes in brain activation patterns are closely related to cognitive performance (Colcombe et al., 2004). In summary, exercising can improve cognitive functions and selectively alter the structure and function of related brain areas.

5.5 Discussion on designing limb exercise trainings to enhance the health of older adults

Physical education is fundamental for developing physical activity. Promoting physical activity requires designing physical training systems for all ages. Physical education is crucial to the physical development of human beings. In particular, health education involves clear educational purposes and aims to change people's behaviour and improve their quality of life. This study focused on the physical and psychological development of older adults and employed various theories and skills from physical training studies to provide these adults with education, consulting, and trainings on physical health knowledge and skills. Consequently, this study assisted them in cultivating regular exercise habits, ensured harmonious physical and psychological development, and improved their physical capacities and cognitive functions.

Combining limb exercises with health education for older adults leads to a comprehensive education system that further enhances conventional nursing skills and exhibits clear health objectives. This system seeks to improve the physical condition, cognitive functioning, and overall health quality of older adults. It provides training programs from diverse perspectives, such as physical skills, cognition, behaviour, and emotions, and incorporates numerous scientific subjects including physical education, psychology, physiology, and nutrition. The objectives of this education system are to help elderly adults cultivate awareness of health as well as to develop regular exercise habits, transform these habits into a part of their daily lives, and maintain or improve health conditions.

Limb exercise training is a scientific training method that involves the preservice training of nursing personnel in caring for older adults and in integrating physical activities with health education. Therefore, the nursing personnel who receive the preservice training must espouse the new training methods that they acquire. In addition, designing whole-body physical activities has added to the flexibility and creativity of the training methods to be employed. Although a concrete system for improving the health of older adults through limb exercise trainings has not been proposed in previous studies, this study aims to develop a plausible system by conducting experiments and incorporating perspectives from different scientific subjects.

Cellular and molecular mechanisms: In discussing the underlying cellular and molecular mechanisms of how exercise training improves cognitive function, most studies have verified and explored these mechanisms through animal model experiments. These mechanisms mainly include the influences of exercise on the viability and function of nerve cells, neuroinflammation, neuroendocrine stress response, and cerebral amyloid burden (Fordyce et al, 1991; Ding et al, 2006; Radak et al, 2007).

Cardiovascular function hypothesis: Exercise induces positive changes in the cardiovascular functions related to cognitive function (including enhancing oxygen saturation and increasing angiogenesis and cerebral blood flow); consequently, cognitive function is improved (Bai et al, 2011).

Brain plasticity hypothesis: This hypothesis considers that cognitive activity is based on activities in the central nerve system, particularly in the brain. Cognitive changes are based on brain plasticity changes. Therefore, the outcome of exercise improving cognitive function occurs because exercise affects brain plasticity. For example, Erickson et al. (Erickson et al, 2011) implemented an aerobic exercise intervention on 120 elderly adults and improved their spatial memory. Furthermore, the aerobic exercise intervention increased hippocampal perfusion and enlarged the volume of the anterior hippocampal. Smith et al. conducted a 12-week moderately-intense treadmill training intervention on MCI patients (Smith et al, 2012), significantly improving learning abilities such as picture identification. In addition, the MRI revealed that when the patients performed semantic memory tests, the activation intensity was decreased in 11 brain areas compared with before the intervention. These results show that exercise training enhances the efficiency of the nerves involved in semantic memory retrieval in MCI patients. Suzuki et al (2013) randomly divided 100 MCI patients into 2 groups: an intervention group who received multimodal exercise training and a control group who received relevant health education. After 6 months, the intervention group achieved improvements in MMSE scores and logical memory. Moreover, the cerebral cortex atrophy area observed in the intervention group was smaller than that observed in the control group. The brain-derived neurotrophic factor (BDNF) measured in the intervention group was higher than before intervention. Therefore, by increasing the BDNF, exercise training is likely to nourish nerves and thereby improve cognitive function.

Social cognitive theory: This theory suggests that performing participants' exercise enhances cognitive function mainly through improving self-esteem, self-efficacy, and sense of control (Chen & Yin, 2011).

Mediating variables hypothesis: This hypothesis proposes that in addition to exerting a direct influence on cognitive function, physical exercise also has an indirect influence on cognitive function through several mediating variables such as physical and mental resources and slowing disease progression (Spirduso, 2009).

Cognitive reserve perspective: Cognitive neuroscience studies have shown that the network connections in the brain area controlling cognitive function are denser and more efficient in individuals with substantial cognitive reserves. When the function in one of the cognitive brain area declines, other brain areas effectively compensate for the declined one, reducing the decrease in cognitive function. Physical exercise provides ample stimuli that enable repeated applications of multiple cognitive processes, facilitating improving cognitive brain networks, and enables exercising individuals to maintain a high level of cognitive reserve; thus, physical exercise provides a basis for mitigating cognitive aging (Stern, 2002). The aforementioned changes in biological, psychological, and social factors propose new ideas regarding the possible mechanisms underlying the result that limb exercise training improves cognitive function.

The aforementioned perspectives from various scientific fields indicate that the limb exercise trainings conducted in this study improved the older adults' physical health through regular exercise, fundamentally changed their exercise habits by adjusting the employed training methods, and thereby created a system for the psychical training of older adults. Therefore, this study demonstrated that limb exercise trainings are a comprehensive training system that improves older adults in various areas, particularly in enhancing their physical condition and cognitive functioning. Limb exercise trainings emphasise the importance of overall health development in these adults. These trainings substantially enhanced their cognitive and fine motor capacities and entailed changing their exercise knowledge and habits. By designing a program of limb exercise trainings, this study fundamentally changed conventional nursing methods and training methods employed to assist older adults in performing exercise. In addition, a variety of training methods were adopted and integrated for older adults to fundamentally influence or change conventional concepts of physical training, physical health knowledge, and physical training methods utilized by nursing personnel.

5.6 Recommendations

5.6.1 Research Limits

Because all research subjects were from the same community, experimental contamination could not be avoided. However, before the intervention, the research subjects were all informed of the research objective and learned that the control group should temporarily refrain from performing limb exercises. During the intervention, the MCI patients in the control group also demonstrated interest in the training method. This phenomenon compounded the difficulty in controlling any confounding factors.

Group limb exercise training required a fixed number of people for the training to proceed. Not all group members could participate in all of the group activity sessions. Therefore, missing members affected the results of the group activities.

a. Because the research sample was small and the researcher adopted a convenience sampling method, further application of these research results was limited.
b. Because of the limited research time, the researcher assessed only the results of a 10-week intervention. The long-term effects of the intervention remain unknown.

5.6.2 Suggestions for Future Research

Physical trainings for older adults must involve considering differences in their individual and residential characteristics. To improve the physical health of an older adult, a dialectical perspective must be used to determine that physical training methods exhibit diversity, consistency, selectivity, and a common foundation.

Dialectically examining the health problems of older adults is highly emphasised; we should neither exaggerate the importance nor underestimate the severity of investigating, analysing, and making judgements regarding their psychological traits, existing problems, and future development. Any theoretical or practical study on elderly adults has a responsibility both to these adults and to society.

Incorporating physical education into the health of older adults is a systematic approach that requires integrating complementary measures such as the preservice training of nursing personnel. Currently, nursing personnel possess a limited ability to conduct physical trainings for patients. Therefore, they require professional preservice trainings, including those to increase their knowledge of physical health and physical training skills, techniques, and methods. In the future, physical training must be promoted, and education on physical training must be implemented. The physical trainings must be designed and developed according to both the specific and general needs of people of all ages. Researchers are advised to develop further knowledge and additional operational techniques related to limb exercise training to facilitate standardising the training methods in order to enhance their treatment effects.

Future researchers are recommended to investigate a larger research sample encompassing multiple centres and to adopt a randomised control design to improve the persuasiveness of the outcomes. In addition, the follow-up time should be extended to observe the long-term effects of the intervention.

This study investigated influences of the limb exercise training intervention on the cognitive function of the MCI patients. The detailed mechanisms require further exploration through animal or neurobiochemical experiments.

5.6.3 Conclusion

This study intervened in the control group, comprising 21 MCI patients, only by distributing health education manuals. Together with the intervention measures used for the control group, 20 MCI patients in the training intervention group additionally completed a 10-week limb exercise training program.

Baseline investigation of the 41 research subjects revealed that the psychomotor speed of the MCI patients was significantly correlated to their cognition level. Psychomotor speed is considered an effective indicator for screening cognitive impairment.

After 10 weeks of follow-up, the psychomotor speed and cognition level of the MCI patients were improved through both measures compared with the conditions before intervention. However, in comparison with the control group, which merely received MCI health education manuals, the MCI patients in the training intervention group were given additional limb exercise training as a means of intervention and the following was observed:

a. The MCI patients achieved more significant improvements in their FTT scores.
b. The MCI patients achieved more significant improvements in their PPT scores.
c. The MCI patients achieved more significant improvements in all dimensions of the MoCA and their total scores.
d. The power values of the alpha and beta EEG waves in all brain areas of MCI patients increased more significantly, implying that limb exercise training positively influenced the patients' brain function.

In summary, the limb exercise training intervention contributed to a more significant improvement in the MCI patients' psychomotor exercise speed; furthermore, the limb exercise training intervention mitigated the decline in cognitive function. Thus, the limb exercise training intervention is effective for community-dwelling MCI patients.

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Appendix A:

香港教育學院

健康與體育學系

參與研究同意書(養老院)

以精神運動速度為依據的老年人體育運動對輕度認知障礙的干預研究

本養老院同意參加由陳適暉博士負責監督,蔣昊負責執行的研究計劃 她/他們是香港教育學院學生/教員

本人理解此研究所獲得的資料可用於未來的研究和學術發表 然而本人有權保護本養老院老年人的隱私,其個人資料將不能洩漏

本人對所附資料的有關步驟已經得到充分的解釋 本人理解可能會出現的風險 本人是自願讓本養老院老年人參與這項研究

本人理解本人及本養老院老年人皆有權在研究過程中提出問題,並在任何時候決定退出研究,更不會因此引致任何不良後果

本人同意讓香港教育學院學生於本校進行與上述研究項目有關之研究。

簽署:

院長/ 養老院代表*姓名: (教授/博士/先生/女士/小姐*)

職位:

養老院名稱:

日期:

香港教育學院

健康與體育學系

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1. 研究目的

本研究目的是通過實驗增加體育鍛煉，旨在提高老年人的精細運動能力、手眼協調能力、身體協調能力、執行能力、注意力及反應速度。此外，本研究試圖設計一套提高認知能力和大腦健康的體育鍛煉指南，從而改善老年人輕度認知障礙。

2. 研究方法

參與人數

將會有 60 名老年人隨機分配到兩組中，每組各三十人。年齡介於 65-70 歲之間。第一組將會進行正常的醫療照顧與日常活動. 第二組將由養老院工作人員的配合下來完成練習，每週三次，每次大約 60 分鐘。

工作及步驟

第一步：以問卷的形式，對大慶市的 2-3 家養老院進行篩查評估。研究員會在發放問卷之前詳細介紹此研究之目的及意義，參與的老年人將簽署知情同意書。研究員將問卷當場發放，大約在半個小時內完成。

第二步: 在進行練習之前進行認知功能和腦電圖的資料收集及手眼協調能力與精細運動能力的測量。

第三步：在最後一次練習（第 10 周第 3 次練習）完成後，所有參與練習的老年人將會再次進行相關測量指標的資料收集。

體育運動練習

如果您同意參加此項研究，您將完成為期十周的體育運動練習。在練習中將會通過上肢練習和下肢練習兩部分進行，上肢練習可通過一些輔助器械進行，旨在發展老年人的上肢的精細運動速度和手眼協調能力；下肢運動可通過一些趣味性的練習來完成，旨在發展老年人的下肢運動能力和執行能力。通過不同的訓練方法已達到本實驗的研究目的，改善老年人的認知能力和大腦健康，從而減緩輕度認知障礙的發生。

利益

這是一項自願參加的研究專案，本次研究並不為閣下提供個人利益，但增強老年人的認知能力和提高生活品質，會給與老年人實際的建議和參考，增加護理工作的滿足感和榮譽感。

3.風險及措施

這是一個自願參加的研究項目，在開始參加練習的一天或兩天內受試者可能會感到肌肉酸痛、疼痛或僵硬。但這是一種正常的運動現象。護理人員將會對受試者及時的解釋清楚，減少其參與實驗的顧慮。參加者有很小的幾率在訓練中造成運動損傷（如肌肉拉傷）。因此，為了降低運動風險，在每節練習中前後各有十分總的熱身活動和放鬆活動。熱身活動旨在儘快提高身體的運動性能減少損傷；放鬆活動旨在釋放雞肉乳酸，防止肌肉疼痛和僵硬。

貴養老院老年人的參與純屬自願性質。所有參加者皆享有充分的權利在研究開始前或後決定退出這項研究，更不會因此引致任何不良後果。凡有關 貴校學生/教師的資料將會保密,一切資料的編碼只有研究人員得悉。

4.研究結果

如果您同意參加此研究項目， 研究員將以論文、期刊、會議演講、組織報告、網路線上報告、口頭報告的形式發佈本研究。

如閣下想獲得更多有關這項研究的資料,請電郵與本人 (s1051424@s.ied.edu.hk)或本人的導師陈适晖博士 (shchen@ied.edu.hk)聯絡。

如閣下對這項研究有任何意見,可隨時與香港教育學院人類實驗對象操守委員會聯絡(電郵: hrec@ied.edu.hk; 地址:香港教育學院研究與發展事務處)

謝謝閣下有興趣參與這項研究。

蔣昊
<首席研究員簽署>

Appendix B:

香港教育學院

健康與體育學系

參與研究同意書

以精神運動速度為依據的老年人體育運動對輕度認知障礙的干預研究

本人___________________同意參加由陳適暉博士負責監督,蔣昊執行的研究項目

本人理解此研究所獲得的資料可用於未來的研究和學術發表　然而本人有權保護自己的隱私，本人的個人資料將不能洩漏

本人對所附資料的有關步驟已經得到充分的解釋　本人理解可能會出現的風險　本人是自願參與這項研究

本人理解我有權在研究過程中提出問題,並在任何時候決定退出研究，更不會因此引致任何不良後果

參加者姓名:

參加者簽名:

日期:

有關資料

以精神運動速度為依據的老年人體育運動對輕度認知障礙的干預研究

誠邀閣下參加陳適暉博士負責監督,蔣昊負責執行的研究計劃　她/他們是香港教育學院學生/教員

1.　研究目的

本研究目的是通過實驗增加體育鍛煉，旨在提高老年人的精細運動能力、手眼協調能力、身體協調能力、執行能力、注意力及反應速度。此外，本研究試圖設計一套提高認知能力和大腦健康的體育鍛煉指南，從而改善老年人輕度認知障礙。

2.　研究方法

參與人數

將會有 60 名老年人隨機分配到兩組中，每組各三十人。年齡介於 65-70 歲之間。第一組將會進行正常的醫療照顧與日常活動. 第二組將由養老院工作人員的配合下來完成練習，每週三次，每次大約 60 分鐘。

工作及步驟

第一步：以問卷的形式，對大慶市的 2-3 家養老院進行篩查評估。研究員會在發放問卷之前詳細介紹此研究之目的及意義，參與的老年人將簽署知情同意書。研究員將問卷當場發放，大約在半個小時內完成。

第二步: 在進行練習之前進行認知功能和腦電圖的資料收集及手眼協調能力與精細運動能力的測量。

第三步：在最後一次練習（第 10 周第 3 次練習）完成後，所有參與練習的老年人將會再次進行相關測量指標的資料收集。

體育運動練習

如果您同意參加此項研究，您將完成為期十周的體育運動練習。在練習中將會通過上肢練習和下肢練習兩部分進行，上肢練習可通過一些輔助器械進行，旨在發展老年人的上肢的精細運動速度和手眼協調能力；下肢運動可通過一些趣味性的練習來完成，旨在發展老年人的下肢運動能力和執行能力。通過不同的訓練方法已達到本實驗的研究目的，改善老年人的認知能力和大腦健康，從而減緩輕度認知障礙的發生。

利益
這是一項自願參加的研究專案，本次研究並不為閣下提供個人利益，但增強老年人的認知能力和提高生活品質，會給與老年人實際的建議和參考，增加護理工作的滿足感和榮譽感。

3.風險及措施
這是一個自願參加的研究項目，在開始參加練習的一天或兩天內受試者可能會感到肌肉酸痛、疼痛或僵硬。但這是一種正常的運動現象。護理人員將會對受試者及時的解釋清楚，減少其參與實驗的顧慮。參加者有很小的幾率在訓練中造成運動損傷（如肌肉拉傷）。因此，為了降低運動風險，在每節練習中前後各有十分總的熱身活動和放鬆活動。熱身活動旨在儘快提高身體的運動性能減少損傷；放鬆活動旨在釋放雞肉乳酸，防止肌肉疼痛和僵硬。

閣下的參與純屬自願性質。閣下享有充分的權利在任何時候決定退出這項研究，更不會因此引致任何不良後果。凡有關閣下的資料將會保密，一切資料的編碼只有研究員得悉。

4.研究結果
如果您同意參加此研究項目，　研究員將以論文、期刊、會議演講、組織報告、網路線上報告、口頭報告的形式發佈本研究。

如閣下想獲得更多有關這項研究的資料,請與蔣昊聯絡,電話 00852-53393711 或聯絡她/他們的導師陳適暉博士,電話 00852-29487865

如閣下對這項研究有任何意見,可隨時與香港教育學院人類實驗對象操守委員會聯絡(電郵: hrec@ied.edu.hk; 地址:香港教育學院研究與發展事務處)

謝謝閣下有興趣參與這項研究

蔣昊

首席研究員

Appendix C:

一般情況調查表

1. 性別　　男 □　　女 □

2. 年齡　　歲

3. 民族：　　漢族 □　　少數民族　□

4. 宗教信仰：　無　□　　有　□

5. 受教育水準：文盲　□　　小學　□　　初中及以上 □

6. 婚姻狀況：　已婚　□　　離異或喪偶 □

7. 職業（退休前)：工人 □　　農民 □　　幹部　□　　軍人 □

教師　□　　私營業主 □　　專業技術人員　□　　其它　□

8. 居住情況：　獨居 □　　夫妻同住 □　　兒女同住 □　　其它 □

9. 經濟狀況：您每月收入情況：

無收入 □　　500 元以下 □　　500~1000 元 □　　1000~1500 元 □

1500~2000 元 □　　2000 元及以上　□

10. 飲食是否規律：否　□　　是　□

11. 是否患有慢性病：

所患疾病名稱：

12. 目前是否服藥： 否 □ 是 □

藥物名稱:

13. 家族史： 癡呆□ 中風 □ 其他 □

14. 您是否飲酒： 否 □ 是 □

15. 您是否吸煙： 否 □ 是 □

16. 您平時是否進行鍛煉： 否 □ 是 □

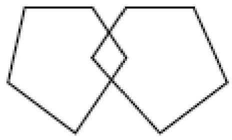
Appendix D:

簡易智力狀態量表（Mini – Mental – state Examination, MMSE）

請回答以下問題，答對者每題記“1”分，答錯或回答不出者記“0”分。

項　　目	評　　分	
	正確	錯誤
1、今年的年份？	1	0
2、現在是什麼季節？	1	0
3、今天是幾號？	1	0
4、今天是星期幾？	1	0
5、現在是幾月份？	1	0
6、你能告訴我下載那我們在哪裡？例如：現在我們在哪個市？	1	0
7、你住在什麼區？	1	0
8、你住在什麼街道？	1	0
9、我們現在是幾樓？	1	0
10、這是什麼地方？	1	0
11、現在我要說三樣東西的名稱，在我講完之後，請你重讀說一遍，請你好好記住這三樣東西，因為等一下我要再問你的（請仔細說清楚，每一樣東西一秒鐘）。“桌子”“石頭”“電話”請你把這三樣東西說一遍（以第一次答案計分） 桌子 石頭 電話	 1 1 1	 0 0 0

12、現在請你從 100 減去 7，然後從所得的數目再減去 7，如此一直計算下去，把沒一個答案都告訴我，直到我說“停”為止。 （若錯了，但下一個答案都是對的，那麼只記一次錯誤）。 93-7=？ 86-7=？ 79-7=？ 72-7=？	 1 1 1 1	 0 0 0 0
13、現在請你告訴我，剛才我要你記住的三樣東西是什麼？ 桌子 石頭 電話	 1 1 1	 0 0 0
14、說出所示物體的名稱 手機（拿出你的手機） 橡皮（拿出你的橡皮）	 1 1	 0 0
15、現在我要說一句話，請清除的重複一遍，這句話是：“四十四只是獅子”（只需說一遍，只有正確，咬字清楚的才記 1 分） 四十四只是獅子	 1	 0
16、（訪問員：把寫有“閉上你的眼睛”的大字卡片交給受訪者）請照著這個卡片縮寫的去做 閉眼睛	 1	 0
17、（訪問員：說下面一段話，並給他一張空白紙，不要重複說明，也不要示範）請用右手拿這張紙，再用雙手把紙對折，讓後將之放在大腿上。 用右手拿紙 把紙對折 放在大腿上	 1 1 1	 0 0 0
18、請你說一句完整的，有意義的句子（句子必須有主語，動詞） 記 下 所 敘 述 的 全 文 ______________________。	 1	 0

句子合乎標準 句子不合乎標準	1	0
19、模仿畫出下圖 （兩個五邊形交叉形成一四邊形） 	1	0
總分:________________		

Appendix E:

日常生活能力量表（ADL）

項目	評分標準			
	自己獨立完成	有些困難	需要幫助	根本無法做
1、使用公共車輛	1	2	3	4
2、行走	1	2	3	4
3、做飯菜	1	2	3	4
4、做家務	1	2	3	4
5、吃藥	1	2	3	4
6、吃飯	1	2	3	4
7、穿衣	1	2	3	4
8、梳頭、刷牙等	1	2	3	4
9、洗衣	1	2	3	4
10、洗澡	1	2	3	4
11、購物	1	2	3	4
12、定時上廁所	1	2	3	4
13、打電話	1	2	3	4
14、處理自己錢財	1	2	3	4

【專案和評定標準】

ADL 共有 14 項，包括兩部分內容：一是軀體生活自理量表，共 6 項：上廁所、進食、穿衣、梳洗、行走和洗操；二是工具性日常生活能力量表，共 8 項：打電話、購物、備餐、做家務、洗衣、使用交通工具、服藥和自理經濟 8 項。

【評定注意事項】

評定時按表格逐項詢問，如被試者因故不能回答或不能正確回答(如癡呆或失語)，則可根據家屬、護理人員等知情人的觀察評定。如果無從瞭解，或從未做

過的專案，例如沒有電話也從來不打電話，記(9)，以後按研究規定處理。

【結果分析】

評定結果可按總分、分量表分和單項分進行分析。總分量低 16 分，為完全正常，大於 16 分有不同程度的功能下降，最高 64 分。單項分 1 分為正常，2-4 分為功能下降。凡有 2 項或 2 項以上≥3，或總分≥22，為功能有明顯障礙。

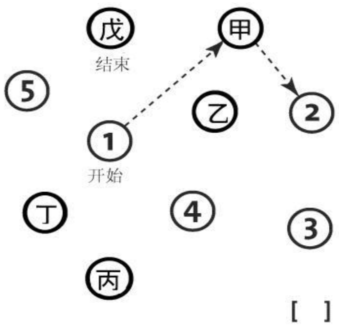
Appendix F:

蒙特利爾認知評估（MoCA）北京版

Montreal Cognitive Assessment (MoCA) Beijing Version
蒙特利尔认知评估北京版

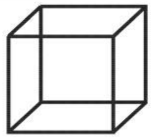
出生日期：
教育水平：
性　　别：
姓名：
检查日期：

视空间与执行功能



[ ]

复制立方体



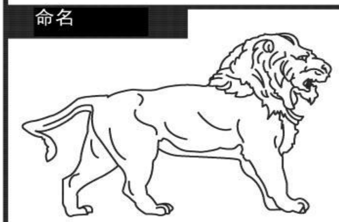
[ ]

画钟表（11点过10分）（3分）

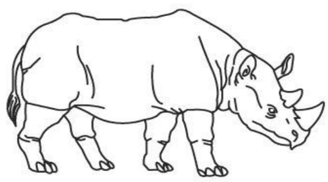
[ ] 轮廓　[ ] 数字　[ ] 指针

得分 ___/5

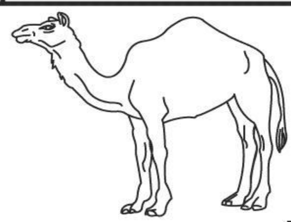
命名



[ ]



[ ]



[ ]

___/3

记忆	读出下列词语,而后由患者重复 上述过程重复2次 5分钟后回忆		面孔	天鹅绒	教堂	菊花	红色	不计分
		第一次						
		第二次						

注意　读出下列数字,请患者重复（每秒1个）
顺背 [ ] 2 1 8 5 4
倒背 [ ] 7 4 2
___/2

读出下列数字,每当数字1出现时,患者必须用手敲打一下桌面,错误数大于或等于2个不给分
[ ] 5 2 1 3 9 4 1 1 8 0 6 2 1 5 1 9 4 5 1 1 1 4 1 9 0 5 1 1 2
___/1

100连续减7　[ ] 93　[ ] 86　[ ] 79　[ ] 72　[ ] 65
4-5个正确给3分,2-3个正确给2分,1个正确给1分,全都错误为0分
___/3

语言　重复：我只知道今天张亮是来帮过忙的人 [ ]
狗在房间的时候，猫总是躲在沙发下面 [ ]
___/2

流畅性：在1分钟内尽可多的说出动物的名字　[ ] ____ (N ≥ 11 名称)
___/1

抽象　词语相似性:如香蕉-桔子=水果　[ ] 火车-自行车　[ ] 手表-尺子
___/2

延迟回忆	回忆时不能提示	面孔 [ ]	天鹅绒 [ ]	教堂 [ ]	菊花 [ ]	红色 [ ]	仅根据非提示回忆计分	___/5
选　项	分类提示							
	多选提示							

定向　[ ] 日期　[ ] 月份　[ ] 年代　[ ] 星期几　[ ] 地点　[ ] 城市
___/6

总分 ___/30

Beijing version 26 August, 2006 translated by Wei Wang & Hengge Xie
www.mocatest.org

Appendix G:

健康教育手冊

——輕度認知功能損害

一、　什麼是輕度認知功能損害？

輕度認知功能損害（MCI）是介於正常老化和老年癡呆之間的一種臨床狀態，特指與年齡、受教育程度不符的認知功能減退，但尚不影響日常生活能力，並尚未達到癡呆的臨床診斷標準。多數老年人群隨著年齡增長一般會經歷不同程度的認知功能下降，特別是在記憶上尤為明顯，只有 1/100 的人會沒有或沒有明顯的認知能力下降。MCI 的概念由 Petersen 領導的研究組於 20 世紀 90 年代提出，具體識別標準包括：(1)主觀報告記憶力下降，最好有知情人提供資訊佐證；(2) 在客觀測試中表現出與年齡和受教育水準不符的記憶功能（或其他認知功能）損傷；(3) 總體認知功能相對完好；(4) 日常生活功能不受影響；(5) 沒有癡呆。

二、　哪些因素與輕度認知功能損害有關？

既往研究已經明確了 MCI 發生的因素，包括不可干預性因素及可干預因素。保護性因素：

高等教育程度、認知刺激性活動、體育鍛煉、飲食因素（單一或多重不飽和脂肪酸）及地中海飲食習慣。

危險性因素：
高齡、APOE ε4 等位基因、男性、低水準的受教育程度、血管性意外（糖尿病、高血壓、肥胖、高血脂及吸煙）、心腦血管疾病（冠心病、房顫、心衰及腦血管疾病）、全身性炎症反應、抑鬱症，焦慮症等精神疾病。

三、　輕度認知功能損害有哪些表現？

輕度認知功能損害的主要表現為認知功能的損傷及精神行為異常。MCI 患者在多項認知功能上存在不同程度的下降，如記憶力、執行能力、定向和視空間能力以及語言和思維能力等，其中記憶功能的損傷最為普遍。MCI 患者不僅表現為認知功能損傷，還伴隨精神行為異常，主要體現為抑鬱情緒、易激怒、情感冷淡、睡眠障礙、激越/攻擊等問題。

四、　如何推遲或延緩輕度認知功能的損害？

大量研究證實輕度認知功能損害具有腦和認知的可塑性，針對其認知損傷開展干預能有效延緩認知功能的下降，防止其向老年癡呆轉化。目前，MCI 干預策略主要包括兩類，即藥物干預及非藥物干預（軀體鍛煉、認知干預及心理干預）為避免或減少藥物的副作用，多數研究推薦 MCI 以非藥物干預為主。其中認知干預中常見的是記憶干預，具體訓練方法包括面孔人名綁定、認知地圖、線索法、分類法、分層組織、位置法、無錯學習以及視覺表像等。MCI 的非認知領域，包括普及預防知識，增加癡呆發生風險意識、穴位按摩、認知訓練、放鬆訓練等。基於我國傳統醫學，國內研究人員還開展了針對 MCI 的中藥和針灸干預研究，並取得了較好的效果。體育運動對認知過程產生廣泛的影響，可以觀察到的最顯著的影響即是執行控制過程，包括計畫、進度安排、工作記憶、抑制、多重任務處理等功能。同時，體育運動作為一種高效性、經濟性及強可及性的干預策略，可顯著降低血管性認知損害患者的認知下降率，且副作用少。