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Mind-body exercise and cognitive function: potential approaches to manage cognitive impairment- a meta-analysis

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MIND-BODY EXERCISE AND COGNITIVE FUNCTION: POTENTIAL APPROACHES TO MANAGE COGNITIVE IMPAIRMENT-A META-ANALYSIS

by

YIN WU

Under the Direction of Dr. Yong Tai Wang and Dr. Elisabeth O. Burgess

ABSTRACT

Cognitive impairment is prevalent among older adults population. It brings restriction to older adults' lives and bring huge burden to the society. Mind-body exercise has characteristics from both physical exercise and intellectual experience. Moreover, it has potential cognitive benefits to reduce the incidence even reverse cognitive impairment. Using meta-analysis to analyze findings form published research on mind-body exercise, this study will explore whether practicing mind-body exercise is beneficial for the management of cognitive impairment.

INDEX WORDS: Mind-body exercise, Tai Chi, Yoga, Older adults, Cognitive function

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CHAPTER 1. INTRODUCTION

1.1 Cognitive impairment and older adults

1.1.1 Prevalence of cognitive impairment

Demographic Change

The rapid growth of aging population in the U.S. signals the most astonishing demographic changes in the history. In the year of 2000, the population of those over 65 years old was approximately 35 million; in the year of 2010, this number has already grown into more than 40 million (Administration on Aging, 2010). In the year of 2000, older adults (who were over 65 years old) constituted 12.4% of the total population in America; in the year of 2010, more than 13 percent of the total population in America was older adults. According to United States Census Bureau (2012), the estimated number of older adults population will be about 47 million by the year of 2015, older adults population will constitute 14.4% of the total population in America; by the year of 2050, America will have more than 88 million older adults, which means that there will be at least one older adult in every five Americans.

The trend of population aging is worldwide, according to Department of Economic and Social Affairs of United Nations, the population of older adults, in the year of 2000, was nearly 494 million, which was more than 8% of the total worldwide population; by the year of 2010, the population of older adults was approximately 630 million, which constituted 9% of worldwide population. In addition, United Nation estimated that by the year of 2050, the population of older adults will grow into 1913 million, which constitute 20% of the whole population (United Nations, Department of Economic and Social Affairs, 2010). Therefore, the needs and concern of this growing older adult population will continue to be of global significance.

Cognitive impairment and old age

Issues of cognitive impairment disproportionately impact older adults. Currently, psychologists stratify older adults into three subgroups based on cognitive functioning status: no cognitive loss; cognitive impairment, no dementia (CIND), and with dementia (Chertkow et al., 2008).

The term CIND is very self-explanatory. When a physician uses this term, he confirms two things: first, the patient does not have dementia; second, the patient has some cognitive impairment. However, what the degree of impairment is, whether functional impairment is present or what the underlying causes might, these factors have not been put into consideration. Another term, mild cognitive impairment (MCI), refers to older people with short- or long-term memory impairment who have no significant daily functional disability (Chertkow et al., 2008). The initial criteria for MCI requires a subjective report of cognitive decline from a former level, gradual in onset, and present for at least 6 months (Petersen et al., 1995). Again, similar to CIND, MCI emphases the presence of cognitive decline, not what caused it.

In the end, if the memory loss is severe and accompanied by significant functional impairment and other cognitive impairments, the patient meets the clinical criteria for dementia, not mild cognitive impairment (Chertkow et al., 2008). Regardless of the level of severity, CIND, MCI and dementia share a common fundamental characteristic, which is cognitive impairment.

In America, approximately 22% of people aged 71 years and older experienced CIND in 2007 (Plassman et al., 2008,) and in 2012, about 18 percent of older adults in the U.S. are suffering from AD and other kinds of dementia (Herbert, Scherr, Bienias, Bennett & Evans, 2003, p.1120), which means that in total, there are about 40 percent of older adults in America have cognitive impairment, regardless of how severe it is. Combined with the demographic change, the high prevalence of cognitive impairment will bring enormous problem to society. For example, aggregate payments for health care, long-term care and hospice for people with dementias are projected to increase from $200 billion in 2012 to $1.1 trillion in 2050. Medicare and Medicaid cover about 70 percent of the costs of care (Alzheimer's Association, 2012, p.39). It is obvious that it is important to manage cognitive impairment.

1.2 Manage cognitive impairment from life –span perspective

Many scientists are working on the topic of how do manage cognitive impairment. From a life-span perspective, researchers consider the development of cognitive functions as a process of lifelong adaption and they investigate the approaches which may have effectiveness throughout the entire lifetime (Willis, Schaie, & Martin, 2012). Intellectual experience, and physical exercise were two of the life-span approaches that influence cognitive functioning (Daffner, 2010; Wilson, Barnes, & Bennett, 2003; Hanna-Pladdy, MacKay, 2011). Mind-body (MB) exercise is combination of physical exercise and intellectual experience.

1.2.1 Physical exercise

According to the evidence from various cross-sectional studies, longitudinal studies and experimental studies, physical exercise has been proved to be a significant factor which can preserve cognitive functions among older adults. Higher physical activity level is positively related to less impaired cognitive functions and less incidence of dementia (Laurin et al., 2001; Pignatti, Rozzini, & Trabucchi, 2002; Stewart, Prince, & Mann, 2003). Among different subcategories of cognitive functions, memory function, especially verbal memory function has the highest sensitivity to the protective effects of physical activity (Stewart, Prince, & Mann, 2003).

Aichberger and colleagues implemented a longitudinal study, they subtracted data from the first and second wave of the Survey of “Health, Aging, and Retirement in Europe (SHARE) in 2004/2005 and 2007/2007” (Aichberger et al., 2010, p. 8). They investigated the influence of being inactive on older adults’ cognitive performance. It was a 2.5 years follow-up research. They used “delayed word recall and semantic verbal fluency test” to measure cognitive function, to be more specific, “memory and executive functioning” (Aichberger et al., 2010, p. 9). Their results indicated that regular exercise can reduce cognitive decline. Especially for people who participated in vigorous exercise more than once a week, the positive effect of physical exercise on both their memory and executive functioning is significant (Aichberger et al., 2010).

As a result, many organizations recommend physical exercise as an approach to prevent cognitive impairment, AD and other dementia, such as Alzheimer Association in many countries (Lautenschlager et al., 2008).

1.2.2 Intellectual experience

In this category, research interests are normally focused on two topics, bilingualism and musical expertise. Shifting between two languages and practicing instruments involves voluntary management of attention, which involves several executive functions: “active inhibition, reactive inhibition, selective attention, and switching” (Green, 1998; Colzato et al., 2008; Costa, 2005; Meuter & Allport, 1999, cited in Bialystok & DePape, 2009, p. 565). In addition, this management of attention is constant. As a result of constantly practice, executive functions involved in voluntary attention management are enhanced, for a wide range of tasks (Costa, 2005; Bislystok & DePape, 2009). Being bilingual and musician have both been proved to have cognitive benefits, especially for executive functions and memory (Bialystok, Craik, Klein, & Wiswanathan, 2004; Hanna-Pladdy & MacKay, 2011). Researchers proposed that these advantages in executive function and memory could protect older adults with intellectual experience from the onset of dementia, and there are more intellectual experience could fit into this pattern (Bialystok, Craik, & Freedman, 2007).

1.3 Mind-Body (MB) exercise and cognitive impairment

MB exercise, which is a subcategory of physical exercise, has been used for a long time in the East and now is increasingly popular in the West (Chan, Ho, Cheung, Albert, Chiu, & Lam, 2005). Comparing to other exercise forms, MB exercise has unique characteristics. “They emphasize the conscious control of each body movement. To pay attention to each movement, the exercises typically involve slow motion. Moreover, a peaceful and relaxed state of mind is required during the practice of MB exercise” (Chan, et al., 2005, p. 1754). Because of these properties, MB exercise can be considered as the combination of physical exercise and intellectual experience, in turn, may have greater cognitive benefits than each of the four approaches discussed above. However, the cognitive benefits of MB exercise have not been well studied.

1.3.1 Four elements of MB exercise

Although there is still no uniformed definition of MB exercise, researchers have identified four elements of MB exercise: a focus on mind, movement, a focus on breathing, and a deeply relaxed state (Larkey. Jahnke, Etnier, & Gonzalez, 2009).

When practicing MB exercise, individuals should clear their thoughts and focus on present moment and the movements practicing (Larkey. Jahnke, Etnier, & Gonzalez, 2009). Body movement of MB exercise is typically described as slow, relaxed and flowing. Besides this common characteristic, movement of MB exercise could vary from highly choreographed forms to free style movement without choreography; from dynamic movement to static postures (Larkey. Jahnke, Etnier, & Gonzalez, 2009). No matter what form of movement the individual is practicing, a focus on breathing is always required. Breathing in MB exercise is not only to bring oxygen into human body, it is also through deep, flowing breathing, one can “bring the mind and consciousness to a restful state” (Larkey. Jahnke, Etnier, & Gonzalez, 2009, p. 232). The last element is a deep state of relaxation, relaxation of body and mind is the key element of MB exercise, it is required for reaching the maximum benefits of practicing, it is also the goal of practicing MB exercise (Larkey. Jahnke, Etnier, & Gonzalez, 2009).

1.3.2 Common MB exercises

In America, two kinds of MB exercise have commonly accepted, they are Tai Chi and Yoga. Tai Chi, also known as Tai Chi Chuan originated from ancient China. It is the combination of ancient Chinese philosophy and martial art. Philosophy of Yin and Yang, two opposing and independent forces (e.g., man and woman, dark and light), is applied into the designing of Tai

Chi movements. Practicing Tai Chi is actually activating the interaction of Yin and Yang energy within human body, it is proposed to make human body function energetically (Chang, Nien, Tsai, & Etnier, 2010). Yoga on the other hand, originated from ancient India, it is an ancient discipline designed to “bring balance and health to the physical, mental, emotional, and spiritual dimensions of the individual” (Ross, & Thomas, 2010, p.3). There are eight elements of Yoga, they are “yama (universal ethics), niyama (individual ethics), asana (physical postures), pranayama (breath control), pratyahara (control of the senses), dharana (concentration), dyana (meditation), and samadhi (bliss)” (Ross, & Thomas, 2010, p.3).

1.3.3 MB exercise for older adults

As one kind of physical exercise, the intensity of MB exercises, such as Tai Chi and Yoga can reach the level of moderate, which indicates those MB exercises, in common with other formats of moderate intensive physical exercises, have physiological benefits, for example, pulmonary functions, and reduced blood pressure (Hong, Li, & Robinson, 2000). Researchers suggest that MB exercise, such as Tai Chi and Yoga, be considered as an alternative to physical exercise (e.g. aerobic exercise and strength training) for older adults who cannot exercise vigorously, in order to reduce the risk of sport-related injuries and cardiac hazards among older adults (Chan, Ho, Cheung, Albert, Chiu, & Lam, 2005). In addition, because of the variability of Tai Chi and Yoga movement (with or without choreography, being dynamic or static), traditional Tai Chi and Yoga can be simplified in general or tailored into exercise which focus on improving function of one or two specific body parts (Kwok et al., 2011). In this way, Tai Chi and Yoga can be more suitable for older adults with different level of physical capacity.

1.4 Mechanism of the cognitive beneficial effects of MB exercise

1.4.1 MB exercise as physical exercise

MB exercise can bring neurological change

As one kind of physical exercise, MB exercise can bring many physiological changes which may reduce even reverse cognitive impairment. Animal studies with mice have demonstrated that physical exercise can sustain and improve brain functions. Physical exercise can increase the number of synapses in the cerebellum (McAuley, Kramer, & Colcombe, 2004), reduce cognitive impairment induced by an increase of oxidative stress and lipid peroxide which subsequently impairs hippocampal neurogenesis (Nakajima et al., 2010). Recently, with the help of modern brain-imaging technologies, such as Voxel-based Morphometric technology, researchers proved that benefits of physical exercise can be also applied to human brain. They found that older adults with higher aerobic fitness showed less gray matter loss in the frontal, temporal, and parietal lobes; less white matter loss in the anterior and posterior tracts (Colcombe et al., 2003); stronger blood flow, and higher level of neuron connectivity (Burdette et al., 2010).

MB exercise can modify cardiovascular disease risk factors

The health of human brain is heavily dependent on the overall health of the heart and blood vessels. A healthy heart can make sure that enough blood is pumped into brain, where contains that richest network of blood vessels of human body, and healthy blood vessels can make sure enough oxygen and nutrition are send to brain. Cardiovascular disease will compromise the health of heart and blood vessels, in turn, compromise the supply system of brain and impair cognitive functions (Alzheimer’s Association, 2012). Three major cardiovascular risk factors are: hypertension, Diabetes Mellitus, and Dyslipidemia, and it has been proved that physical exercise can modify these risk factors (Li, Fisher, & Harmer, 2005; Auer, 2004; Ng, Tai, Goh, & Wee, 2011; Fillit, Nash, Rundek, & Zuckerman, 2008).

1.4.2 MB exercise as an intellectual experience

Comparing to other forms of physical exercises, MB exercise involves more cognitive functioning during practice, such as meditation, active attention on movement, and memorize formats. Long-term and repetitive activation of theses cognitive functioning allow MB exercise practicing bring cognitive benefits in the way that bilingual and musical expertise do, which is enhancement in one cognitive function can be generalized into other domains (Bialystok, Craik, & Freedman, 2007)

.

1.5 Objective and hypothesis

There are several studies documented the cognitive benefits of MB exercise, however, most of this studies had small sample size, the objective of the study is to verify the cognitive benefits of MB exercise based on results from existing studies.

There are four hypotheses in this study:

(1) MB exercise has cognitive benefits over global cognitive status for older adults. In a cross-sectional study, Chan et al. (2005) compared memory function between MB exercise practitioners who were older adults and older adults without regular exercise habit. Based on participant’s score of The Hong Kong List Learning Test, they found a strong association between MB exercise practice and better memory function.

(2) MB exercise has cognitive benefits over attention for older adults. In a cross-sectional

study, Man et al. (2005) found out among 42 older adults, based on their scores of color trail test A and B, MB exercise practitioners had better attention than their counterparts who did not practice MB exercise.

(3) MB exercise has cognitive benefits over executive function for older adults. In a10-week interventional study, researchers found that participants in the experiment group who practiced Tai Chi during the study had significant improvement in executive function based on their performance in Trailmaking B Test and Clock Drawing Test (Matthews & Williams, 2008).

(4) MB exercise has cognitive benefits over memory for older adults. In a one group pre-test and post-test interventional study, researchers (Chang et al., 2011) found a dose-response relationship between MB exercises practicing and memory function of older adults, higher dosage resulted in better performance in Digit Span Test.

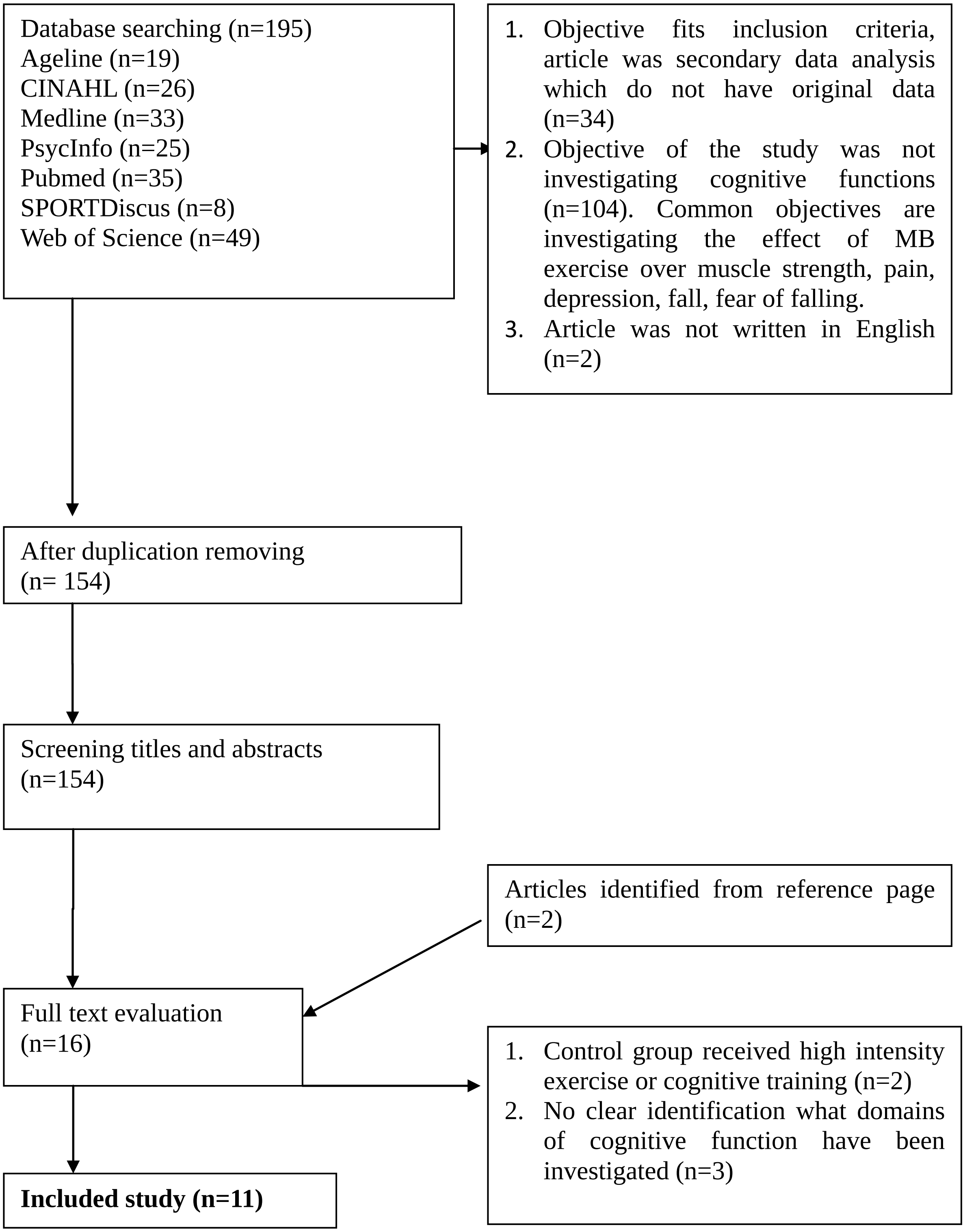
CHAPTER 2. METHODS

2.1 Selection of Studies

Studies that investigated the possible cognitive benefits of MB exercise were identified through a computerized search of all electronic databases: AgeLine, CINAHL, MedLine, PsycINFO, PubMed, SPORTDiscus, and Web of Science. Articles published from January 1st 1992 to July 1st 2012 were included in this study. Relevant keywords relating to cognitive function (‘cognitive’ or ‘cognition’ or ‘cognitive function’) were used in combination with words relating to MB exercise (‘mind-body’ or ‘mind-body exercise’ or ‘Tai Chi’ or ‘yoga’) and words relating to study subjects (‘older adults’ or ‘elderly’).

One investigator (YW) assessed all potentially relevant articles for eligibility. The decision to include or exclude was made based on the following information: (1) the study title; (2) the study abstract; and (3) the complete study manuscript.

Eligible studies were included if they met all of the following criteria: (1) study had original data; (2) the effect of MB exercise over cognitive function was the primary or secondary outcome; (3) research subjects were older adults (55 years and older); (4) clear definitions of domains of cognitive function and methods used to assess cognitive performance were reported; (5) reported all data required for meta-analysis, for interventional studies with experiment and control groups, required data included sample size of experiment group and control group, mean score and standard deviation of pre-test of experiment group and control group, mean score and standard deviation of post-test of experiment group and control group (in case data of pre-and post-test scores were not reported, mean score and standard deviation of change between two tests of experiment group and control group are required); for interventional study with one group, required data included sample size, mean score and standard deviation of both pre-and post-test (in case data of pre-and post-test scores were not reported, mean score and standard deviation of change between two tests are required; for cross-sectional studies, required data included sample size of both experiment and control groups, mean score and standard deviation of tests of experiment and control groups; (6) article was written in English or translated into English; (7) participants in control group should had no exercise or low intensity exercise such as stretching, and muscle toning.



Database searching (n=195)
Ageline (n=19)
CINAHL (n=26)
Medline (n=33)
PsycInfo (n=25)
Pubmed (n=35)
SPORTDiscus (n=8)
Web of Science (n=49)

1. Objective fits inclusion criteria, article was secondary data analysis which do not have original data (n=34)
2. Objective of the study was not investigating cognitive functions (n=104). Common objectives are investigating the effect of MB exercise over muscle strength, pain, depression, fall, fear of falling.
3. Article was not written in English (n=2)

After duplication removing
(n= 154)

Screening titles and abstracts
(n=154)

Articles identified from reference page (n=2)

Full text evaluation
(n=16)

1. Control group received high intensity exercise or cognitive training (n=2)
2. No clear identification what domains of cognitive function have been investigated (n=3)

Included study (n=11)

Figure 1 Flow Chart of Searching Strategy

2.2 Data Extraction

All data were reviewed and separately extracted by YW using a standardized form in Excel. The following study characteristics were recorded if they were available: author, year of publication, type of study, type of MB exercise, frequency and duration of intervention for interventional studies, and years of practicing and frequency for cross-sectional studies.

2.3 Data Analysis

For each study, a standardized mean difference, d, was calculated for reported outcome measures of interest (Hedges & Olkin, 1985; Morris, 2000). The value d is an indication of effect size (ES). For two-group interventional studies, it expresses the difference of change between pre-test and post-test between experiment group and control group. For one group interventional studies, ES is the difference between test scores of pre-test and post-test. For cross-sectional studies, ES is the difference of test score between two cohorts. A positive value for ES indicates more favorable outcome scores for the group of interest, a negative ES indicates more favorable outcome for the control group. Usually, researchers define ES as small (ES=0.2), medium (ES=0.5), and large (ES=0.8) (Cohen, 1988, p.25).

All calculated ESs were adjusted for sample size. Each ES was weighted by the inverse of its sampling variance in order to grant more weight to studies having larger number of participants. Normal-theory standard errors were used to construct 95% confidence intervals (CIs) for the ES and to test if the ES was significant.

For each outcome subgroups, ES homogeneity of variance was tested using a conventional heterogeneity statistic, Q. It is calculated as the weighted sum of squared differences between individual study effects and the pooled effect across studies. Q is distributed as a chi-square statistic with freedom of number of studies minus 1.

The analyses of overall ESs were implemented using random-effects model (Hedges & Vevea, 1998). Random-effects model assumes that ES of individual studies vary due to both sampling error within each study and other sources of study-level error such as difference among interventions. This model analyzes the implementation of each study as a random realization from a group of studies that might have been reported. As a result, with this model, even though samples included in meta-analysis have different features, they can still be generalized. Random effects model is most appropriate in situations where study implementation is heterogeneous (Raudenbush, 1994), which is true considering studies included in this meta-analyses study.

CHAPTER 3. RESULTS

3.1 Searching Result

The searches in the electronic databases were performed on June 29, 2012. After excluding duplication, 154 articles were retrieved. Sixteen of which were identified after evaluating titles and abstracts of the articles. After evaluating the full text of the articles, two studies were excluded because the intervention included a control group who received high intensity of exercise or cognitive training; three studies were removed due to lack of identification of what domains of cognitive function has been investigated. A total of 11 studies were included in this meta-analysis (See Table 3.1) .(Chan et al., 2005; Chang et al., 2011; Kasai et al., 2010; Kwok et al., 2011; Lam et al., 2009; Lam et al., 2010; Man et al., 2010; Matthews & Williams, 2008;

Mortimer et al., 2012; Oken et al., 2006; Prakash et al., 2011) Among these 11 studies, four were cross-sectional studies (Chan et al., 2005; Lam et al., 2009; Man et al., 2010; Prakash et al., 2011); seven were interventional studies (Chang et al., 2011; Kasai et al., 2010; Kwok et al., 2011; Lam et al., 2010; Matthews & Williams, 2008; Mortimer et al., 2012; Oken et al., 2006) . For meta-analysis, in the study of Lam et al. (2009), Tai Chi practitioners were stratified into two groups based on the years of practicing, this study were treated as two independent sets of data in meta-analysis. In the study of Chang et al. (2011), participants naturally separated into two group based on intervention compliance, high dosage group and low dosage group, these two groups were treated as experiment group and control group in meta-analysis.

3.2 Sample Characteristics

3.2.1 Participants

Eleven studies involved 1081 participants who were older adults (55 and older). In nine studies, more than 90 percent participants were women; however, one trail had 66.7 percent female participants (Mortimer et al., 2012), and one trial did recruit all male participants (Prakash et al, 2011). Regarding the cognitive capacity of participants, most studies excluded older adults with dementia or other severe psychological condition; however, two studies investigated cognitive benefits of MB exercise specifically for older adults with MCI (Kasai et al., 2010; Chang et al., 2011).

Table 3.1 Included Studies

Study	Type of study	Participants		Content of group of interest	Content of Control group	Cognitive functions of interest	Tests
		Sample size	Cognitive capacity				
Prakash et al. (2011)	Cross-sectional	E: n=20 C: n=20	No dementia	Yoga more than 1 hour per day in last 10 years	No exercise	Memory Executive Attention	DSF, DSB TMA, TMB Stroop test Letter cancelation test Digital symbol test Rule shift test
Chan et al. (2005)	Cross-sectional	E: n=35 C: n=35	No dementia	MB exercise mean value of practicing is 6.7 hours per week	No regular exercise	Global cognitive status Memory	DRS Boston naming test Hong Kong list learning test
Man et al. (2010)	Cross-sectional	E: n=42 C: n=44	No dementia	Tai Chi Mean value of Tai Chi practicing is 7.8 years	No exercise	Global cognitive status Memory Attention	MMSE Hong Kong list learning test RBMT Color trail test
Lam et al., (2009)	Cross-sectional	E1: n=54 E2: n=36 C: n=229	No dementia	Tai Chi E1: practice > 5 years E2: practice < 5 years	No dementia	Global cognitive status Memory	MMSE ADAS-cog DSF, DSB Delay recall Category verbal fluency test

Table 3.1 Included Studies

Study	Type of study	Participants		Content of group of interest	Content of Control group	Cognitive functions of interest	Tests
		Sample size	Cognitive capacity				
Mortimer et al. (2012)	Interventional	E: n=30 C: n=30	No dementia	Tai Chi 50min/day 3day/week 40weeks	No exercise	Memory Executive Attention	DSF, DSB TMA, TMB Stroop test Rey figure test Bell cancelation test Auditory verbal learning Boston naming test CDT DRS Category verbal fluency
Kwok et al., (2011)	Interventional	E: n=20 C: n=20	No dementia	Tai Chi (simplified) 40min/day 1day/week 8weeks	Stretching	Global cognitive status	MMSE DRS
Lam et al., (2010)	Interventional	E: n=135 C: n=194	No dementia	Tai Chi 30min/day (3+)days/1week 1year	Stretching Toning	Global cognitive status Memory Executive	MMSE ADAS-cog Category verbal fluency Delay recall DSF, DSB VSF, VSB TMA, TMB

Table 3.1 Included Studies

Study	**Type of study**	**Participants**		**Content of group of interest**	**Content of Control group**	**Cognitive functions of interest**	**Tests**
		Sample size	**Cognitive capacity**				
Oken et al., (2006)	Interventional	E: n=38 C: n=42	No dementia	Yoga 90min/day 1day/week 6month	No exercise	Attention Memory	Stroop test Word list delay recall
Kasai et al., (2010)	Interventional	E: n=13 C: n=13	With MCI	Tai Chi 2sessions/week 4weeks/month 6months	No exercise	Memory	RBMT DSF, DSB Subjective memory complaint scale
Matthews & Williams, (2008)	Interventional	N=20	No dementia	Tai Chi 30 sessions over 10 weeks	No exercise	Executive	TMA, TMB CDT Digit symbol substitution
Chang et al., (2011)	Interventional	High dosage: N=8 Low dosage: N=3	With MCI	Tai hi (20-40)min/day 2days/week 15weeks	Low dosage	Global cognitive status Memory Attention	MMSE Digit span Digit symbol coding Stroop test Hopkins verbal learning delay recall test Hopkins verbal learning immediate recall test

3.2.2 Type of MB exercise

Among cross-sectional studies, one was about Yoga (Prakash et al., 2011), two were about Tai Chi (Man et al., 2010; Lam et al., 2009), and one study investigated MB exercise without specifying the type of exercise performed (Chan et al., 2005). Among seven interventional studies, six studies adopted Tai Chi interventions, only one had intervention with Yoga (Oken et al., 2006). Within Tai Chi interventions, one was simplified Tai Chi intervention (Kwok et al., 2011).

3.2.3 Quantity and Quality of MB exercise

Quantity and quality both will affect cognitive benefits of MB exercise practicing. Quantity and quality of MB exercise are discussed separately for interventional studies and cross-sectional studies below.

Quantity in interventional studies

The quantity of MB exercise practicing included in each study was different due to two reasons: different length of study and different frequency of intervention implementation. (a) Length of studies: interventions lasted from eight weeks (Kwok et al., 2011) to 48 weeks (Lam et al., 2010). (b) Frequency of interventions: in terms of how many time was the MB exercise implemented in one week, the number varied from 1 (Oken et al., 2006; Kwok et al., 2011) time to more than 3 times a week (Lam et al., 2010).

Quality in interventional studies

All studies only provided limited information about the quality of their MB exercise practicing. However, the quality is as important as the quantity regarding if interventions can achieve the maximum cognitive benefits. Only with both the standard movement and appropriate practicing, which contents the four basic elements of MB exercise (a focus on mind, slow and smooth movement, a focus on breathing, and a deeply relaxed state), the quality of MB exercise practicing can be guaranteed. Quality of MB exercise practicing in interventional studies varied because different qualification of instructors and different amount of exercise was unsupervised. (a) Instructors: responsibilities of instructors included teaching exercise movements and supervising practicing. Having the right instructor is crucial for the quality. In all the studies except one (Chang et al., 2011), exercise was directed by an instructor. However, among studies, the instructor could be a physical therapist, certified instructor, or Tai Chi master. Those instructors may have had different understanding of MB exercise, different master level of MB exercise, and different focus during their teaching and supervising. So, even though 10 out of 11 studies had an instructor, quality may still vary significantly. (b) Practicing without supervision: when participants practice MB exercise without supervision, the quality could not be guaranteed. Three studies mentioned that there were practicing without supervision (Oken et al., 2006; Kasai et al., 2010; Matthews & Williams, 2008). The rest eight studies did not provide information about practicing without supervision.

Quantity and quality in cross-sectional studies

Among four cross sectional studies, investigated time frame was 10 years (Prakash et al., 2011), 7.8 years (Man et al., 2010), less and longer than 5 years (Lam et al., 2009), and one undefined (Chan et al., 2005).

Three cross-sectional studies have not identified the frequency of MB exercise practicing. One study mentioned the average time of practicing in one week was 6.7 hours (Chan et al., 2005). Since cross-sectional study only investigates MB exercise practicing without supervision, there was no control over the quality.

3.2.4 Control group

The ES calculated by meta-analysis is an indicator of the difference between experiment group and control group; therefore, content of control group may also affect ES. Control group participants in most studies received no exercise; however, two interventional studies included low dosage of stretching and muscle toning in their control groups (Kwok et al., 2011; Lam et al., 2010).

3.2.5 Neurological tests

All 11 studies used different numbers of neuropsychological tests. The number of tests in each study varied from two to 12. In addition, studies tested different domains of cognitive function, researchers tested different combination of global cognitive status, memory function, executive function and attention. Neurological tests and which domain do they address are summarized in table 3.2.5.

Table 3.2.5 Neurological Tests

Global Cognitive Status	Attention	Executive Function	Memory Function
Mini Mental Status Examination (MMSE) Dementia Rating Scale (DRS) Alzheimer's Disease Assessment Scale-cognitive subscale (ADAS-cog	Stroop Word-Color Test (SWC)	Trailmaking Test part A (TMA) Trailmaking Test part B (TMB)	Digit Span Test forward (DSF) Digit Span Test backward (DSB) Visual Span Test backward (VSB) Verbal Fluency Test (VFT) Word Delay Recall Test (WDR)

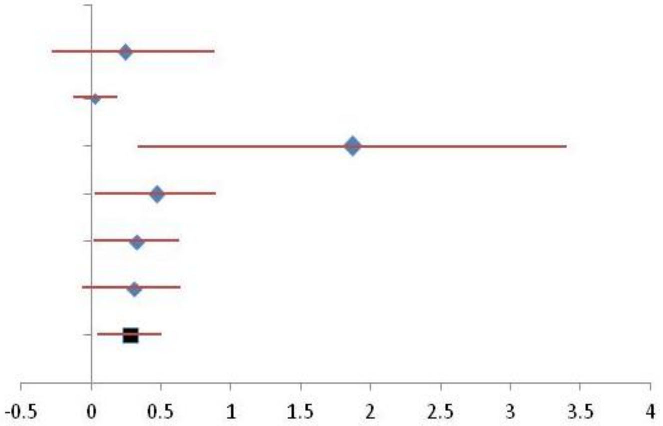
3.3 Meta-analysis

From the 26 psychological tests in the sample studies, 11 were selected for meta-analysis. In order to be included in the meta-analysis, there had to be at least three sets of data. Tests included in this meta-analysis were: Mini Mental Status Examination (MMSE), Dementia Rating Scale (DRS), Alzheimer's Disease Assessment Scale-cognitive subscale (ADAS-cog), Stroop Word-Color Test (SWC), Trailmaking Test part A (TMA), Trailmaking Test part B (TMB), Digit Span Test forward (DSF), Digit Span Test backward (DSB), Visual Span Test backward (VSB), Verbal Fluency Test (VFT), and Word Delay Recall Test (WDR).These tests measure general cognitive status, attention, executive function, and memory. Meta-analysis results of 11 tests were summarized and presented in forest plots blow.

3.3.1 MMSE

Five trials involving 785 participants used MMSE (Chang et al., 2011; Kwok et al., 2011; Lam et al., 2009; Lam et al., 2010; Man et al., 2010). Since in the study of Lam et al. (2009), Tai Chi practitioners were stratified into two groups based on the years of practicing, this study were treated as two independent sets of data in meta-analysis, there were in total six sets of data. Three sets of data were from interventional studies (Chang et al., 2011; Kwok et al., 2011; Lam et al., 2010) and the rest three sets of data were from cross-sectional studies. Overall, there was significant difference between experiment group and control group in MMSE score (95%CI, 0.06-0.50, p<0.05), the mean ES was 0.28 (table 3.3.1), it was considered as a small ES.

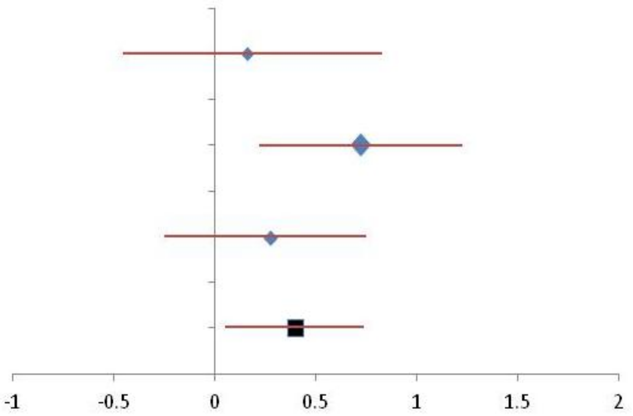
Table 3.3.1 Forest Plot of MMSE

Effect Size					Effect Size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Kwok et al.	9.42%	0.25	-0.38	0.88	
Lam et al (2010)	29.30%	0.03	-0.18	0.25	
Chang et al.	1.96%	1.87	0.33	3.41	
Man et al.	16.04%	0.47	0.04	0.90	
Lam et al (2009) (>5years)	23.33%	0.33	0.03	0.63	
Lam et al (2009) (<5 years)	19.94%	0.31	-0.04	0.66	
Total	100%	0.28	0.06	0.50	Test for overall effect: Z=2.5107 (p<0.05)
Heterogeneity: Q=9.31, df=5, C=137.28, T^2=0.03					

3.3.2 DRS

Three trials involving 170 participants used DRS (Chan et al., 2005; Kwok et al., 2011; Mortimer et al., 2012). Two sets of data were from interventional studies (Kwok et al., 2011; Mortimer et al., 2012) and one set of data was from cross-sectional study. Overall, there was significant difference between experiment group and control group in DRS score (95%CI, 0.07-0.73, p<0.05), the mean ES was 0.40 (table 3.3.2), which was considered as a small ES.

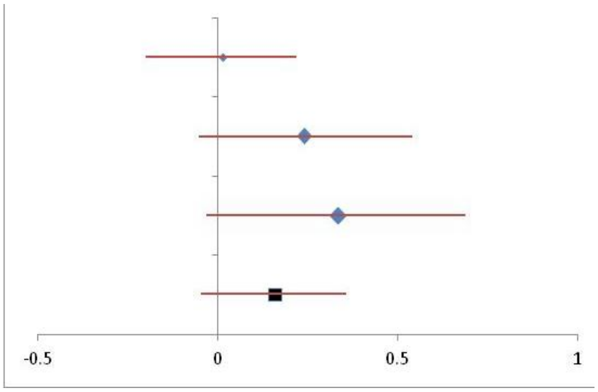
Table 3.3.2 Forest Plot of DRS

<table>
<tr><th colspan="5">Effect Size</th><th>Effect size</th></tr>
<tr><th rowspan="2">Studies</th><th rowspan="2">Weight</th><th colspan="3">Random, 95%CI</th><th rowspan="2">Random, 95% CI</th></tr>
<tr><th>ES</th><th>Low</th><th>High</th></tr>
<tr><td>Kwok et al.</td><td>24.11%</td><td>0.16</td><td>-0.47</td><td>0.80</td><td rowspan="3">
</td></tr>
<tr><td>Mortimer et al.</td><td>34.53%</td><td>0.72</td><td>0.20</td><td>1.24</td></tr>
<tr><td>Chan et al.</td><td>41.35%</td><td>0.27</td><td>-0.20</td><td>0.74</td></tr>
<tr><td>Total</td><td>100%</td><td>0.40</td><td>0.07</td><td>0.73</td><td>Test for overall effect: Z=2.40 (p<0.05)</td></tr>
<tr><td colspan="6">Heterogeneity: Q=2.27, df=2, C=27.28, T^2=0.01</td></tr>
</table>

3.3.3 ADAS-cog

Two trials involving 648 participants used ADAS-cog (Lam et al., 2009; Lam et al., 2010). Since in the study of Lam et al. (2009), Tai Chi practitioners were stratified into two groups based on the years of practicing, this study were treated as two independent sets of data in meta-analysis, there were in total three sets of data. One set of data was from interventional study (Lam et al., 2010) and two sets of data were from cross-sectional study. Overall, there was no significant difference between MB exercise and control groups in the ADAS-cog score (95%CI, -0.04-0.35, p=0.11), the mean ES was 0.16 (table 3.3.3).

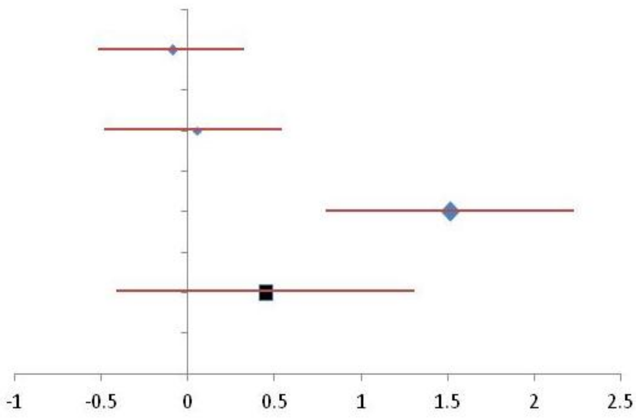
Table 3.3.3 Forest Plot of ADAS-cog

Effect Size					Effect Size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Lam et al. (RCT)	46.33%	0.02	-0.20	0.23	
Lam et al. (CS:>5)	30.50%	0.24	-0.06	0.54	
Lam et al. (CS:<5)	23.18%	0.35	-0.02	0.69	
Total	100%	0.16	-0.04	0.35	Test for overall effect: Z=1.60 (p=0.11)
Heterogeneity: Q=2.88, df=2, C=95.42, T^2=0.01					

3.3.4 SWC

Three trials involving 180 participants used SWC (Mortimer et al., 2012; Oken et al., 2006; Prakash et al., 2011). Two sets of data were from interventional studies (Mortimer et al., 2012; Oken et al., 2011) and, one set of data was from cross-sectional study. Overall, there was no significant difference between experiment group and control group in SWC score (95%CI, -0.4-1.30, p=0.30), the mean ES was 0.45 (table 3.3.4).

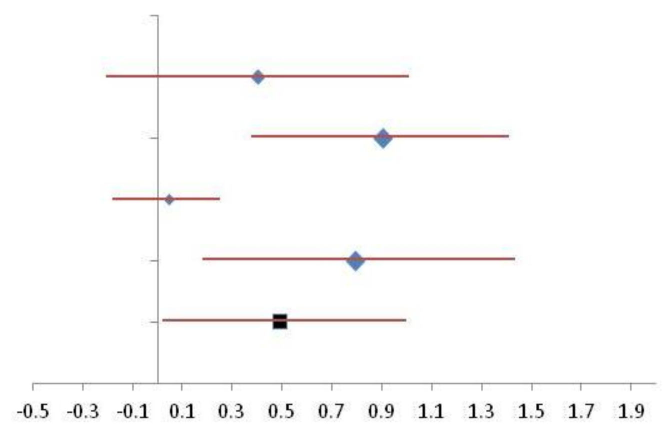
Table 3.3.4 Forest Plot of SWC

Effect Size					Effect size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Oken et al.	35.20%	-0.09	-0.53	0.35	
Mortimer et al.	34.14%	0.05	-0.45	0.56	
Prakash et al.	30.67%	1.51	0.81	2.22	
Total	100%	0.45	-0.40	1.30	Test for overall effect: Z=1.04 (p=0.30)
Heterogeneity: Q=15.21, df=2, C=27.48, T^2=0.48					

3.3.5 TMA

Four trials involving 449 participants used TMA (Kwok et al., 2011; Lam et al., 2010; Matthews & Williams, 2008; Prekash et al., 2011). Three sets of data were from interventional studies (Kwok et al., 2011; Lam et al., 2010; Matthews & Williams, 2008) and one set of data was from cross-sectional study. Overall, there was significant difference between MB exercise and control groups in TMA score (95%CI, 0.02-0.97, $p<0.05$), the mean ES was 0.49 (table 3.3.5), it is considered as medium ES.

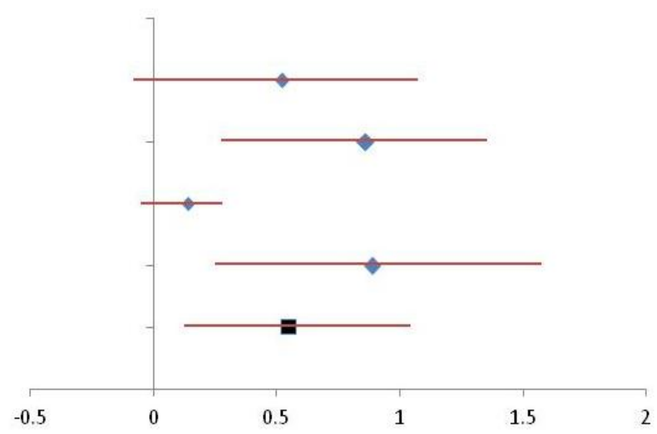
Table 3.3.5 Forest Plot of TMA

Effect Size					Effect Size
		Random, 95%CI			
Studies	Weight	ES	Low	High	Random, 95% CI
Matthews & Williams	21.75%	0.40	-0.23	1.02	
Kwok et al.	24.32%	0.90	0.37	1.43	
Lam et al.	32.64%	0.05	-0.17	0.26	
Prekash et al.	21.28%	0.80	0.15	1.44	
Total	100%	0.49	0.02	0.97	Test for overall effect: Z=2.03 ($p<0.05$)
Heterogeneity: Q=12.16, df=3, C=54.57, T^2=0.17					

3.3.6 TMB

Four trials involving 449 participants used TMB (Kwok et al., 2011; Lam et al., 2010; Matthews & Williams, 2008; Prekash et al., 2011). Three sets of data were from interventional studies (Kwok et al., 2011; Lam et al., 2010; Matthews & Williams, 2008) and one set of data was from cross-sectional study. Overall, there was significant difference between experiment group and control group in TMB score (95%CI, 0.12-1.01, p<0.05), the mean ES was 0.55 (table 3.3.6), it was a medium ES.

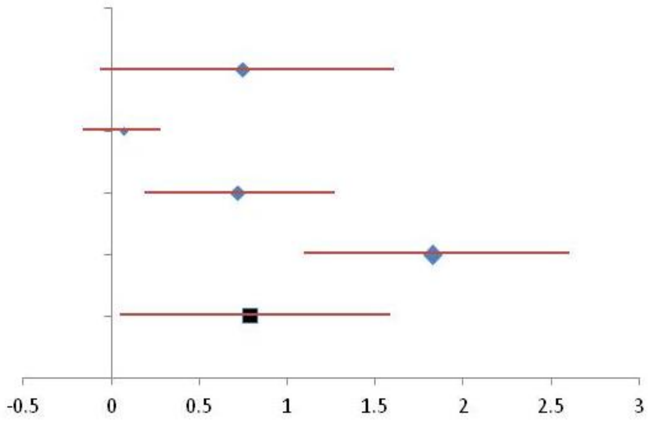
Table 3.3.6 Forest Plot of TMB

Effect Size					Effect Size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Matthews & Williams	20.87%	0.52	-0.11	1.15	
Kwok et al.	24.09%	0.86	0.33	1.39	
Lam et al.	34.75%	0.14	-0.07	0.36	
Prekash et al.	20.29%	0.89	0.24	1.54	
Total	100%	0.55	0.12	1.01	Test for overall effect: Z=2.51 (p<0.05)
Heterogeneity: Q=9.80, df=3, C=54.58, T^2=0.13					

3.3.7 DSF

Four trials involving 455 participants used DSF (Kasia et al., 2010; Lam et al., 2010; Mortimer et al., 2012; Prakash et al., 2011). Three sets of data were from interventional studies (Kasia et al., 2010; Lam et al., 2010; Mortimer et al., 2012) and one set of data was from cross-sectional study. Overall, there was significant difference between experiment group and control group in DSF score (95%CI, 0.06-1.52, p<0.05), the mean ES was 0.79 (table 3.3.7), it was considered as a large ES.

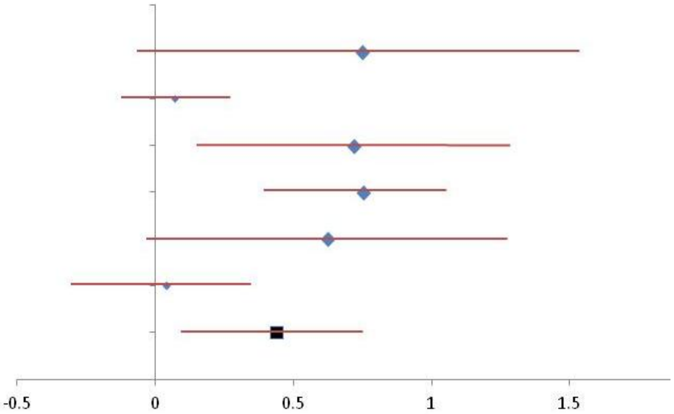
Table 3.3.7 Forest Plot of DSF

Effect Size					Effect Size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Kasai et al.	22.02%	0.75	-0.05	1.54	
Lam et al. (2010)	29.19%	0.07	-0.14	0.29	
Mortimer al.	25.93%	0.72	0.20	1.24	
Prakash et al.	22.86%	1.83	1.09	2.57	
Total	100%	0.79	0.06	1.52	Test for overall effect: Z=2.14 (p<0.05)
Heterogeneity: Q=24.34, df=3, C=46.69, T^2=0.46					

3.3.8 DSB

Five trials involving 774 participants used DSB (Kasia et al., 2010; Lam et al., 2010; Lam et al., 2009; Mortimer et al., 2012; Prakash et al., 2011). Since in the study of Lam et al. (2009), Tai Chi practitioners were stratified into two groups based on the years of practicing, this study were treated as two independent sets of data in meta-analysis, there were in total six sets of data. Three sets of data were from interventional studies (Kasia et al., 2010; Lam et al., 2010; Mortimer et al., 2012) and three sets of data were from cross-sectional studies. Overall, there was significant difference between experiment group and control group in DSB score (95%CI, 0.12-0.76, p<0.01), the mean effect size was 0.44 (table 3.3.8), it was medium.

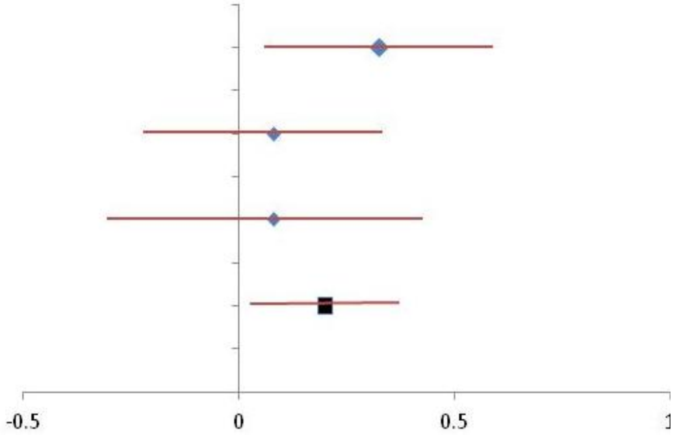
Table 3.3.8 Forest Plot of DSB

Effect Size					Effect Size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Kasai et al.	9.92%	0.75	-0.05	1.54	
Lam et al. (2010)	22.52%	0.07	-0.14	0.29	
Mortimer et al.	15.10%	0.72	0.20	1.24	
Lam et al. (2009) (>5years)	20.49%	0.75	0.45	1.05	
Prakash et al.	12.70%	0.62	-0.01	1.26	
Lam et al. (2009) (<5years)	19.28%	0.04	-0.31	0.39	
Total	100%	0.44	0.12	0.76	Test for overall effect: Z=2.68 (p<0.01)
Heterogeneity: Q=19.51, df=5, C=134.16, T^2=0.11					

3.3.9 VSB

Two trials involving 648 participants used VSB (Lam et al., 2009; Lam et al., 2010). Since in the study of Lam et al. (2009), Tai Chi practitioners were stratified into two groups based on the years of practicing, this study were treated as two independent sets of data in meta-analysis, there were in total three sets of data. One set of data was from interventional study (Lam et al., 2010) and two sets of data were from cross-sectional studies Overall, there was significant difference between experiment group and control group in the DSB score (95%CI, 0.03-0.37, p<0.05), the mean ES was 0.20 (table 3.3.9), it was considered as a small ES.

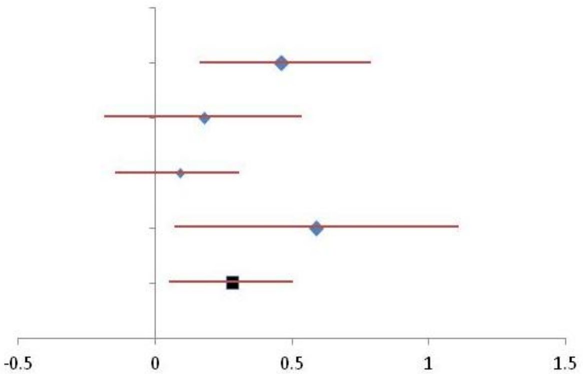
Table 3.3.9 Forest Plot of VSB

Effect Size					Effect size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Lam et al. (2010)	48.94%	0.33	0.11	0.54	
Lam et al. (2009) (>5years)	29.29%	0.08	-0.22	0.38	
Lam et al. (2009) (<5years)	21.77%	0.08	-0.27	0.43	
Total	100%	0.20	0.03	0.37	Test for overall effect: Z=2.26 (p<0.05)
Heterogeneity: Q=2.37, df=2, C=96.16, T^2=0.004					

3.3.10 VFT

Three trials involving 708 participants used VFT (Lam et al., 2009; Lam et al., 2010; Mortimer et al., 2012). Since in the study of Lam et al. (2009), Tai Chi practitioners were stratified into two groups based on the years of practicing, this study were treated as two independent sets of data in meta-analysis, there were in total four sets of data. Two sets of data were from interventional studies (Lam et al., 2010; Mortimer et al., 2012) and two sets of data were from cross-sectional study. Overall, there was significant difference between experiment group and control group in VFT score (95%CI, 0.06-0.51, p<0.05), the mean ES was 0.28 (table 3.3.10), it was a small ES.

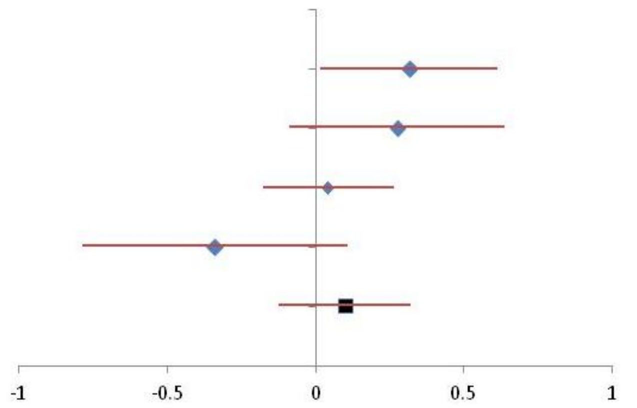
Table 3.3.10 Forest Plot of VFT

Effect Size					Effect Size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Lam et al. (2009) (>5 years)	27.49%	0.46	0.16	0.76	
Lam et al. (2009) (<5 years)	23.10%	0.18	-0.17	0.53	
Lam et al. (2010)	35.55%	0.09	-0.13	0.31	
Mortimer et al.	13.86%	1.59	0.07	1.11	
Total	100%	0.28	0.06	0.51	Test for overall effect: Z=2.49 (p<0.05)
Heterogeneity: Q=5.70, df=3, C=113.24, T^2=0.02					

3.3.11 WDR

Three trials involving 728 participants used WDR (Lam et al., 2009; Lam et al., 2010; Oken et al., 2006). Since in the study of Lam et al. (2009), Tai Chi practitioners were stratified into two groups based on the years of practicing, this study were treated as two independent sets of data in meta-analysis, there were in total four sets of data. Two sets of data were from interventional studies (Lam et al., 2010; Oken et al., 2006) and two sets of data were from cross-sectional study. Overall, there was no significant difference between experiment group and control group in DSB score (95%CI, -0.14-0.34, p=0.41), the mean effect size was 0.10 (table 3.3.11).

Table 3.3.11 Forest Plot of WDR

Effect Size					Effect Size
Studies	Weight	Random, 95%CI			Random, 95% CI
		ES	Low	High	
Lam et al. (2009) (>5years)	26.60%	0.32	0.02	0.62	
Lam et al. (2009) (<5years)	22.94%	0.27	-0.07	0.63	
Lam et al. (2010)	32.50%	0.04	-0.18	0.26	
Oken et al.	17.97%	-0.34	-0.78	0.10	
Total	100%	0.10	-0.14	0.34	Test for overall effect: Z=0.82 (p=0.414)
Heterogeneity: Q=7.15, df=3, C=119.43, T^2=0.03					

CHAPTER 4. DISCUSSION

Considering the combination of significance and ES, results from the present meta-analysis showed that MB exercise has cognitive benefits over executive function and memory function, especially verbal working memory. The difference of global cognitive status between experiment group and control group was statistically significant, but the ES was very small. There was no difference of attention between experiment group and control group.

4.1 Domains of cognitive function

Based on results for meta-analysis, neurological tests were stratified into three groups: tests showed no significance, tests show significance and small ES, and tests showed significance and medium to large ES. These three groups were showed in table 4.1. Then results from meta-analysis were discussed within different domains of cognitive function.

Table 4.1 Significance and ES of Each Neurological Test

Neurological Test	Significance	ES
Tests Showed No Significance		
ADAS-cog	P=0.11	0.16
SWC	P=0.3	0.45
WDR	P=0.41	0.1.
Tests Showed Significance and Small ES		
MMSE	P<0.05	0.28
DRS	P<0.05	0.40
VSB	P<0.05	0.2
VFT	P<0.05	0.28
Tests Showed Significance and Medium to Large ES		
TMA	P<0.05	0.49
TMB	P<0.05	0.55
DSF	P<0.05	0.79
DSB	P<0.01	0.44

4.1.1 General Cognitive Status

First hypothesis was MB exercise has cognitive benefits over global cognitive status. MMSE, DRS and ADAS-cog evaluate the global cognitive function level of subjects. They have been widely used as screening tools to identify participants with dementia or severe cognitive impairment. They all have different parts looking into specific domains of cognitive function such as executive function, memory, processing speed and attention.

Results from this meta-analysis showed that after practicing MB exercise, participants demonstrated statistical significant improvements in MMSE and DRS scores, but not ADAS-cog scores. In addition, the overall effect sizes calculated from MMSE and DRS were 0.28 and 0.4 respectively. The overall effect sizes were both considered as small. Therefore, this hypothesis was not supported.

Before the onset of dementia, older adults usually do not show noticeable decline in global cognitive function. Even when MCI or CIND is identified, which indicates the presence of cognitive impairment, older adults still can remain a normal level of global cognitive status (McGough et al., 2011). In seven trails which implemented these three tests, no participant had dementia, and only 11 participants from one trail (Chang et al., 2011) had MCI. This means that older adults in this sample all had relatively good global cognitive functions at baseline, as the result, no significant improvement after practicing MB exercise is understandable.

4.1.2 Attention

The second hypothesis was MB exercise has cognitive benefits over attention. Attention is the cognitive process that allows human concentrating on one aspect of the environment while ignoring other things. Also, attention has been referred to as the allocation of processing resources. (Anderson, 2004). Decline in attention capacity brings difficulties such as poor dual-task performance and having trouble with learning new information. Results from this meta-analysis showed that there was no statistical significant improvement in attention for MB exercise practitioners. Examining the three studies that measured attention capacity of older adults, three individual effect sizes were -0.09 (Oken et al., 2006), 0.05 (Mortimer et al., 2012), and 1.51 (Prakash et al., 2011). These effect sizes were contradictory. Among three effect sizes, one was negative and small, one was positive and small, and one was positive and very large. This high heterogeneity may be a result of variance between studies. In order to verify the true cognitive benefit of MB exercise over attention, more data is required. Therefore, this hypothesis was not supported.

4.1.3 Executive Function

The third hypothesis was MB exercise has cognitive benefits over executive function. Implementation of goal-directed behaviors is heavily relayed on executive function, for older adults, “impairment in executive function could bring difficulties in goal-directed activities such as medication adherence, cooking, housekeeping, and motor tasks performed in a complex environment” (McGough et al., 2011, p. 1199). TMA and TMB have been widely used to investigate executive function. After practicing MB exercise, participants have showed significant improvement in their performances in both TMA and TMB, indicating that MB exercise has cognitive benefits over executive function for older adults.

The calculated overall effect sizes for TMA and TMB were 0.49 and 0.55, respectively. It means that the effect of practicing MB exercise in managing impairment in executive function is considered as medium for older adults. Therefore, this hypothesis was supported.

4.1.4 Memory

The last hypothesis was MB exercise has cognitive benefits over memory function. Five tests were used to measure memory function of older adults in these 11 trails. They were DSF, DSB, VSB, VFT, and WDR. Older adults have shown statistical significant improvement in test scores in all tests except for WDR. The common characteristic of these five tests is that they all measures short-term memory. However, each of these tests looks into more specific aspect of short-term memory; for example, DSF and DSB are measurements for verbal working memory, meanwhile VSB measures non-verbal working memory. The differences between these 5 tests are beyond the scope of this meta-analysis study, will not be discussed here.

Examining the effect size calculated for each test, practicing MB showed great effect on DSF (Overall ES=0.79), moderate effect on DSB (overall ES=0.44), mild effect on VSB and VFT (overall ES=0.2 and 0.28, respectively). The ES calculated form DSF was the only one near 0.8, which is the threshold between medium and large ES. Therefore, this hypothesis was supported.

Based on statistical significance and ES calculated from these five tests, in general, MB exercise could be considered as beneficial for memory functions for older adults; especially for verbal working memory, which is a cognitive system that responsible for the temporary storage and manipulation of information (Baddeley, 2003). This finding is important because verbal working memory is involved in many daily tasks, from remembering sequence of numbers such as phone numbers while writing them down, to understanding long and difficult sentences in order to have a conversation; in addition, verbal working memory is also one of the cognitive functions which are most sensitive to decline in old age (Hertzog, Dixon, Hultsch & MacDonald, 2003).

To summarize, results from this meta-analysis showed that cognitive benefits of practicing MB exercise are over executive function and memory (verbal working memory). Findings of this meta-analysis are resonating with what researchers have found about physical exercise in general, which is among different subcategories of cognitive functions, executive function, and memory function (especially verbal memory function) have the highest sensitivity to the protective effects of physical activity (Aichberger et al., 2010; Stewart, Prince, & Mann, 2003).

4.2 Conclusions

4.2.1 Stronger strength of results

Strength of results from this meta-analysis are greater than single small sample study. Studies included in this meta-analysis mostly had small sample size, even though they have findings with statistical significance, the true value of their findings were restricted, and their conclusion could not be generalized for the whole older adults population. After combining their results, and weighted based on sample size, results from this meta-analysis has more value for the whole elderly population. For example, in the study of Mortimer et al. (2011), sample size was 60, individual ES calculated for VFT from this study was 1.59, which was a very large ES. However, after combining four sets of data, results based on 708 older adults showed that the overall ES calculated from VFT was only 0.28, which was considered as small. This suggests that meta-analysis is a useful tool for understanding the real value of ES of subject of interest. Especially when the subject has not been well studied, and most related researches were small sample.

4.2.2 Potential benefits for managing AD

Decline in memory function is a major risk factor of AD (Modrego, 2006).After the onset of Alzheimer's disease, memory function will be the first domain of cognitive function that be affected, and be deteriorated the most during the whole course of Alzheimer's disease (Alzheimer's Association, 2012). Since MB exercise can improve memory function of older adults, practicing MB exercise might be able to reduce the incidence of AD, even slow down its progression after the onset of AD.

Protective effect of MB exercise over executive function also may reduce the incidence of AD. Decline in executive function is not a major risk factor for AD, however, it is strongly associated with the early deterioration of physical performance in individuals with amnesic MCI (McGough et al., 2011). Older adults with lower level of physical performance are less likely engaging in physical exercise and more likely to adapt to a sedentary life style; unfortunately, researchers have found that inactive older adults have significant higher chance of developing AD and other kinds of dementia than their physically active counterparts (Aichberger et al., 2010).

4.2.3 MB exercise could be an alternative option for older adults

Comparing to other formats of physical exercise such as aerobic exercise and strength training, MB exercise is much easier for older adults to practice, because the typical movement of MB exercise is slow, relaxed, smooth (Larkey. Jahnke, Etnier, & Gonzalez, 2009). MB exercise is safer to practice because it requires less strength and endurance, and the intensity is moderate; therefore, the incidence of sport-related injury and cardiac hazard will be reduced (Chan et al., 2005). MB exercise is also cheaper to practice because it does not require any tools, it only takes an open space and quite environment to practice MB exercise. In conclusion, since the present meta-analysis showed that MB exercise has similar cognitive benefits to physical exercise in general (over memory function and executive function), it may be an alternative of other formats of physical exercise such as aerobic exercise and strength training.

4.3 Limitations

This meta-analysis has limitations, due to limited data and variance between studies.

The only variable in this meta-analysis was neurological test, 11 subgroups were formed based on what neuropsychological tests have been used. Within each subgroup, biggest subgroup has 6 sets of data, and 5 subgroups only had 3 sets of data. It was impossible to included more variables into this study. However, there were still many other variables could affect the cognitive benefits of practicing MB exercise; for example: intensity of each session, total time of practicing, type of exercise (Tai Chi or Yoga), and quality of practicing (if MB exercise has been practiced in the standard way with four basic elements).

In order to investigate those variables, more studies and more detailed information are needed. Since this meta-analysis overlooked these variables, generalized different studies, and combined findings together, results from this study was biased. For example, studies with intervention typically have small sample size, short time frame, and more control over the quality of MB exercise practicing; on the other hand, cross-sectional studies typically have large sample size, long time frame, and less control over quality of MB exercise practicing. Since for each ES, weight distributed based on number of studies included and sample size of each study. Every overall ES calculated in this meta-analysis was favoring either short-term, relatively high quality of MB exercise practicing, or long-term practicing of MB exercise with no quality control.

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