EFFECTS OF TAI CHI PRACTICE THROUGH VIRTUAL TRAINING ON ATTENTIONAL INHIBITION AND RESPONSE INHIBITION AMONG STUDENTS OF USM, KELANTAN, MALAYSIA

CHANG SHU CHUAN

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by

CHANG SHU CHUAN

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LIST OF ABBREVIATIONS

AD	Alzheimer's disease
BG	Brisk walking group
CG	Control group
CPT	Continuous Performance Test
DTI	Diffusion Tensor Imaging
EF	Executive functions
fMRI	functional magnetic resonance imaging
fNIRS	Functional near-infrared spectroscopy
IFG	Inferior frontal gyrus
IPH	Institute for Public Health
M1	Primary motor cortex
NHMSs	National Health & Morbidity Survey
oxy-Hb	Oxygen–hemoglobin
PA	Physical activity
PAR-Q	Physical Activity Readiness Questionnaire
PE	Physical exercise
SMA	Supplementary motor area
STN	Subthalamic nucleus
TCC	Tai Chi Chuan
TG	Tai Chi group
TMS	Transcranial magnetic stimulation
TMT	Trail Making Test
VST	Victoria Stroop test

WM	Working memory
WMS-R	Weschler Memory Scale – Revised

LIST OF APPENDICES

KESAN AMALAN TAI CHI MELALUI LATIHAN SECARA MAYA TERHADAP PENYEKATAN PERHATIAN DAN PENYEKATAN RESPONS DI KALANGAN PELAJAR USM, KELANTAN, MALAYSIA

ABSTRAK

Pengenalan: Tai Chi terbukti berkesan dalam meningkatkan kognisi kerana ia merupakan senaman minda-badan yang menggabungkan aliran pergerakan serta teknik pernafasan. Dalam kajian ini, Tai Chi telah digunakan untuk mengkaji kesannya terhadap perencatan tindak balas dan perencatan perhatian di kalangan orang dewasa muda yang sihat.

Metodologi: Ini adalah kajian intervensi dengan kaedah persampelan kemudahan. Populasi sasaran adalah pelajar dari Pusat Pengajian Pergigian dan Sains Kesihatan di Universiti Sains Malaysia, Kubang Kerian. Semua peserta telah memenuhi kriteria dan lulus kedua-dua ujian saringan. Terdapat dua ujian saringan iaitu Ujian Buta Warna Ishihara dan Soal Selidik Kesediaan Aktiviti Fizikal (PAR-Q). Saiz sampel kajian ini terdiri daripada 31 (F =21, M =10) orang peserta. Intervensi dilakukan menggunakan Tai Chi gaya Yang yang merupakan versi ringkas Tai Chi. Penilaian pra dan pasca intervensi dilakukan melalui tugas Antisaccade yang mengukur perencatan tindak balas dan tugas carian visual yang mengukur perencatan perhatian. Kedua-dua tugas Antisaccade dan tugas carian Visual telah dilakukan dengan menggunakan alat penjejak mata. Untuk menganalisis data yang dikumpul, kedua-dua SMI BeGaze dan Pakej Statistik untuk Sains Sosial versi 26 telah digunakan. Ujian statistik yang digunakan untuk menganalisis data yang dikumpul ialah ujian-t sampel berpasangan.

Hasil Kajian: Dalam kedua-dua tugas kognitif, masa tindak balas dan ketepatan peserta diambil. Bagi tugasan penyekatan respon, terdapat peningkatan yang signifikan dalam ketepatan dan masa tindak balas antara penilaian pra dan pasca. Terdapat perbezaan yang signifikan dalam ketepatan bagi pra intervensi (M=10.27, SD=8.72) dan pasca intervensi (M=.86, SD=1.66); t(30)=-6.17, p <.001. Terdapat perbezaan yang signifikan dalam masa tindak balas untuk sebelum intervensi (M=230.99, SD=265.10) dan selepas intervensi (M=157.78, SD=144.75); t(1633)=-10.04, p <.001. Untuk tugasan penyekatan perhatian, terdapat peningkatan yang ketara dalam masa tindak balas antara penilaian pra dan pasca tugas carian Visual tetapi bukan ketepatan. Tidak terdapat perbezaan yang signifikan dalam ketepatan dalam markah sebelum intervensi (M=.89, SD=1.46) dan selepas intervensi (M=.32, SD=.80); t(30)=-1.83, p = 0.07. Terdapat perbezaan yang signifikan dalam masa tindak balas sebelum intervensi (M= 634.84, SD=465.66) dan selepas intervensi (M=462.92, SD=364.48); t(962)=-172.93, p <.01.

Kesimpulan: Latihan Tai Chi yang digunakan dalam kajian ini dapat meningkatkan kognisi dengan ketara, terutamanya dalam tugasan penyekatan tindak balas dari segi ketepatan dan masa tindak balas manakala dalam tugasan penyekatan perhatian hanya dari segi masa tindak balas dalam kalangan pelajar universiti yang sihat.

EFFECTS OF TAI CHI PRACTICE THROUGH VIRTUAL TRAINING ON ATTENTIONAL INHIBITION AND RESPONSE INHIBITION AMONG STUDENTS OF USM, KELANTAN, MALAYSIA

ABSTRACT

Introduction: Tai Chi was shown to be effective in improving cognition as it is a mind-body exercise which incorporates the flow of the movements as well as breathing technique. In the current study, Tai Chi was used to act the intervention in order to study its effect on response inhibition and attentional inhibition among healthy young adults.

Method: This is an interventional study with convenience sampling method. The target population was students from School of Dental and Health Sciences in Universiti Sains Malaysia, Kubang Kerian. All participants had fulfilled the subject criteria and passed both the screening tests. There were two screening tests which were the Ishihara Color Blindness Test and Physical Activity Readiness Questionnaire (PAR-Q). The sample size of this study consisted of 31 (F =21, M =10) participants. The intervention was carried out using Yang-styled Tai Chi which is simplified version of Tai Chi. Pre and post assessments included Antisaccade task that measure response inhibition and Visual search task that measure attentional inhibition. Both Antisaccade task and Visual search task were done with the use of eye tracker. To analyse the collected data, both SMI BeGaze and Statistical Package for Social Sciences version 26 were utilized.

Results: The statistical test that was used to analyse the collected data was paired sample t-test. In both cognitive tasks, participants' response time and accuracy were included. For response inhibition, there were significant improvements in accuracy and response time between pre and post assessment.

There was a significant difference in the accuracy for pre intervention (M=10.27, SD=8.72) and post intervention (M=.86, SD=1.66); t(30)=-6.17, p < .001. There was a significant difference in the reaction time for pre intervention (M=230.99, SD=265.10) and post intervention (M=157.78, SD=144.75); t(1633)=-10.04, p < .001. For attentional inhibition, there was a significant improvement in response time between pre and post assessment of Visual search task but not n accuracy. There was no significant difference in the accuracy for pre intervention (M= .89, SD=1.46) and post intervention (M=.32, SD=.80); t(30)=-1.83, p = 0.07. There was a significant difference in the reaction time for pre intervention (M= 634.84, SD=465.66) and post intervention (M=462.92, SD=364.48); t(962)=-172.93, p < .01.

Conclusions: Tai Chi training used in this study was able to significantly improve cognition, particularly response inhibition in terms of accuracy and reaction time while attentional inhibition in terms of reaction time among USM students.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This section discusses detailed background to this study which explains the connection between physical activities and executive functions. Tai Chi, eye tracker, and two cognitive assessments which are Antisaccade Task and Visual Search Task were included in this study. The latter part of the write up includes problem statement and study rationale. Lastly, this chapter ends with the research questions, general objectives, specific objectives, and alternative and null hypotheses of this study.

1.2 Background of study

Malaysia has amended the Youth Societies and Youth Development Act that outlines young adults' age to be below 30 years old (Bernama, 2019). Comparing the lifestyle adopted by current young adults with the previous, the young adults nowadays seem to have become inactive nationwide due to the work and study nature. Due to their inactiveness, they are having an progressively less healthy life (Owen et al., 2010). Hence, they might be more vulnerable to experience avoidable diseases like overweight, obesity which might leads them to disorders such as dysmetabolic disorders or tumors (Mitchell and Byun, 2014). In other words, individuals who are less physically active are more susceptible to health-related and even our cognitive related issues.

1.3 Problem statement

In various countries, the occurrence of obesity has extended to an epidemic level and Malaysia is of no exemption. Based on previous National Health and

Morbidity Surveys (NHMSs) carried out in 2006, 2011 and 2015, there is a cumulative trend of overweight and obesity popularity among adults in this nation. When we talk about adults, we include young adults aged 18 years and older (see figure 1) (Institute for Public Health, 2006, 2011, 2015):

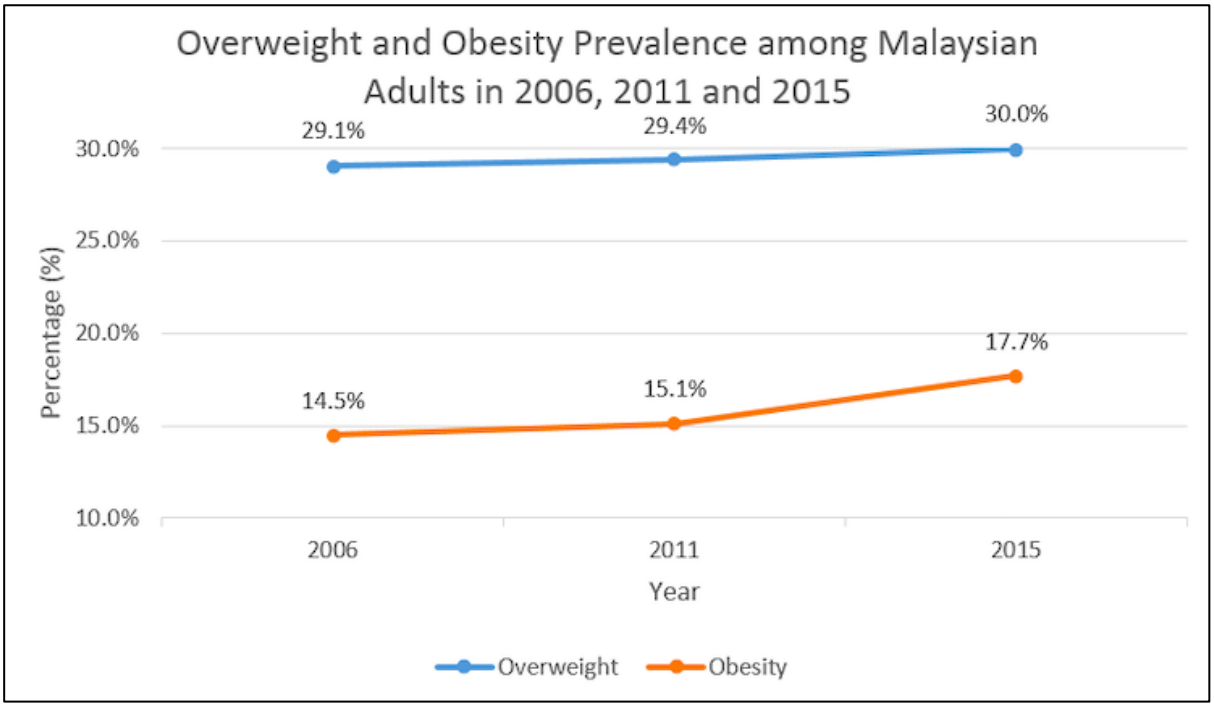

Figure 1.1 showed trend of overweight and obesity prevalence in 2006, 2011 and 2015.

For obese or overweight people, the lower the response inhibition the more they are unable to suppress their cravings towards high-calorie foods and hence they always fail in their weight loss plans (Blume et al., 2019). Inhibitory control or also known as self-control can be reflected on the behavioral level and cognition level through attention (Blume et al., 2019) . Due to their lower inhibition control compared to normal weight individuals, obese individuals might be hard to resist high-calorie food and hard to involve in long term exercises.

Meanwhile, due to the current era, total time to spend on our mobile phones, televisions, electronic gadgets are more than the total time taken on exercising. This

is worrying as it cause youngsters to have less time for sport or any other physical deeds (Corder et al., 2015). Although past studies have proven that physical activity positively helps in the progress and evolution among humankind, younger generations nowadays have very limited time to perform physical exercise.

Physical exercise (PE) is said to be effective in influencing cognition and wellbeing due to its effect on brain plasticity (Fernandes et al., 2017). There are a number of studies validated that PE result in changes of brain structures. A significant one will be the increment of grey matter volume in both frontal and hippocampal regions. With the increment of the grey matter, it helps to lessen impairment of the grey matter areas among adults (Erickson et al., 2014). PE also aids in releasing neurotrophic factors. Due to the movements of the body, it increases the blood flow and helps to mend cerebrovascular health too. Another important benefit is that by attending physical exercises, it helpts to regulate the amount of glucose as well as the metabolism of lipid molecules in the brain (Hötting et al., 2016; Mandolesi et al., 2017). These structural changes in the brain resulted the improvements of cognitive functioning (Hötting and Röder, 2013). As a matter of fact, the results of past studies exhibited that PE helps to strengthen cognition among both young and older adult by showing improvement in their memory score, rate of attentional processes as well as the executive functions (Chieffi et al., 2017; Fernandes et al., 2017).

Mind-body exercise as a part of physical exercises has been found out that not only improve the physical status of practitioners, their cognitive performances will be enhanced too. Some common examples of mind-body exercises are Qigong, Yoga, Tai Chi, and Pilates. Mind-body exercises act as the current trend are preferred by youngsters as the exercise involve lower intensity movements such as stretching

and relaxation of skeletal muscles, as well as coordinated body and regular breathing movements. In addition, mind-body exercise is said to have included meditative states that helps to regulate one's attention and consciousness (Zou et al., 2018). Futhermore, mind-body exercise is also helpful in remedying diseases such as mental illnesses, mood disorders and balance problems.

1.4 Study rationale

In this study, Tai Chi which as mentioned above is one of most practiced traditional Chinese martial arts was selected. Reason being that it is an aerobic mind-body exercise which ranges from mild to moderate before advanced physical movements. Tai Chi was commonly practiced by elders as it does not involve very vigorous or swift changes in movements. Due to its nature, Tai Chi could act as a starter especially for exercise-naïve individuals. It is common among elders but the population should not be restricted. Tai Chi practitioners require both mind concentration and shifting the balance of body with its moderate smooth movements and steady breathing. Since past studies have suggested its efficacy in improving physical health and cognition performances like memory and executive functions (Tsai *et al.*, 2013; Cheng *et al.*, 2014; Li *et al.*, 2014; Lyu *et al.*, 2018), current study would like to find out its effects on inhibition among young healthy adults.

Besides, an alarming disease known as dementia is growing and act as a affliction remaining in this slowly ageing society. One of the misconceptions about dementia is that dementia could only happen to elderly. However, a global report done in 2015 mentioned that there is between 2 to 8 percent of dementia cases affect younger people (World Alzheimer Report, 2015). The higher number of elderly suffering from dementia has resulted lesser community to understand and notice the importance of its occurrence among younger patients (Rossor et al., 2010). Although

diagnosis of the disease, which is dementia is distressing at no matter which age but an increasing diagnosis among younger patients is very distressing and worrying (Rossor et al., 2010). The discrepancy of dementia diagnosis is extensive as late presentation of the metabolic disease of dementia is common. But, the problem arise when the onset of dementia is higher in young patients compared to in patients with later onset (Rossor et al., 2010). One of the most common primary dementia, Alzheimer's disease (AD) which shows one of the early clinical symptoms of forgetting episodic memory. The brain structure of the patients could show changes as early as 20 or more years before the clinical symptom appear (Villemagne et al., 2013). So, to see if Tai Chi could act as one of the strategies in delaying cognitive decline and to improve cognitive functions become one of the rationales in this study (Iuliano et al., 2019).

In the current study, Tai Chi was used to study its effect on cognitive functions, particularly response inhibition and attentional inhibition. Current study showed important implication that if subjects who practice Tai Chi showed improvements in the cognitive functions, Tai Chi could be introduced to youngsters to slow down the decline in cognitive functions and act as a physical exercise that could hold back the onset of dementia as well as to improve body health conditions.

From the past studies, Tai Chi exercise have resulted improvements on the cognition and memory specifically among elderly and clinal samples (Kwok et al., 2011; Lam et al., 2009). However, the effects of Tai Chi exercise on cognition did not indicate uniformity. There were very limited studies on the cognitive effects of Tai Chi over healthy adults. Specifically, Tai Chi helps to improve in attention (Man et al., 2010) as well as inhibitory control among elderly(Yang et al., 2020). However, there were also contradict study suggested that Tai Chi could only help to improve

motoric training but not cognitive functions (Gerritsen et al., 2020; Kim et al., 2016). Hence, this study intends to fill in the gap to study the effects of Tai Chi on cognitive functions like response inhibition and attentional inhibition among young healthy adults.

Furthermore, with the use of eye tracker in this study, it could be the first few studies that study the effect of Tai Chi on cognitive functions. Since the mind-body exercise has been treated as a holistic approach, by using a neuroscience technique to study its effect, researchers are able to understand better about the effects of Tai Chi. The results of the study do not only help to add knowledge in the related field, it could act a starter for Malaysia to implement Tai Chi as a therapy to help in improving cognitive functions.

1.5 Research questions

1.5.1 What is the effect of Tai Chi on attentional inhibition among young healthy adults?

1.5.2 What is the effect of Tai Chi on response inhibition among young healthy adults?

1.6 Objectives

1.6.1 General Objectives

To study the effect of Tai Chi on attentional and response inhibitions among healthy young adults in USM with the help of eye-tracker

1.7 Objectives

1.7.1 To determine the effect of Tai Chi on response inhibition via pre and post intervention phase.

1.7.2 To investigate effect of Tai Chi on attentional inhibition via pre and post intervention phase.

1.8 Hypotheses

1.8.1

$H1_0$: Young healthy adults showed significant improvements in response inhibition after Tai Chi intervention.

H1a: Young healthy adults showed significant improvements in response inhibition after Tai Chi intervention.

1.8.2

$H2_0$: Young healthy adults did not show significant improvements in attentional inhibition after Tai Chi intervention

H2a: Young healthy adults did not show significant improvements in attentional inhibition after Tai Chi intervention.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Current study aimed to investigate the effect of Tai Chi training on response inhibition and attentional inhibition in young adults. This chapter provides an overview of previous studies on Tai Chi training and its effects on cognition particularly inhibitory control. This literature review starts by discussing the physical exercise, mind-body exercises, followed by how Tai Chi has the effects on inhibitory control.

2.2 Physical exercises

Physical exercises (PE) is often confused by the public with terms physical activity (PA). This interchange is incorrect as the terms have different meaning. PA is described as any body movements made by skeletal muscles and involved dynamism spending (Burkhalter and Hillman, 2011). PA is further defined as any motor behavior such as day-by-day or leisure activities and it is regarded as a determinant lifestyle for general health (Burkhalter and Hillman, 2011). PA can be considered an umbrella term and PE is one of the sub classifications of PA.

On the other hand, PE is planned, organized, systematized and recurring. PE has an intermediate or ultimate goal that is mainly to improve one's physical fitness (Burkhalter and Hillman, 2011). Some examples of PE are such as aerobic acitivty and anaerobic activity that both exhibit the same characteristics that are to be have precise frequencies, period and strength.

The American College of Sports Medicine (ACSM) defines aerobic exercise is a type of activity that involves different parts of muscle and can be maintained by

continuous, rhythmic form (Patel et al., 2017). Exercises typically thought of as aerobic consist of cycling, hiking, jogging, dancing, swimming and walking. Instead, anaerobic exercise is considered as an forceful movement done in a brief period of time, highly involving the contraction of muscles and independent of the use of inhaled oxygen as the source of energy (Patel et al., 2017).

2.3 Mind-body exercises

In recent years, growing researches have suggested that regular exercise or physical activity have improved both physical and psychological health (Wu et al., 2013). Specifically, mind-body exercises was suggested to show both improvements in physical health and in cognition(Zheng et al., 2015). Improvements on balance and flexibility through mind-body exercises could be due to the inclusion of components like concentrating on physical movements and controlling breathing (Lam et al., 2009).

2.3.1 Tai Chi

There are a wide range of mind-body exercises like Yoga, Pilates, Tai Chi, Baduanjin, and Wuqinxi that showed improvements on physical and cognition abilities. Tai Chi specifically spark researcher's interest as it involves flowing and slow dance-like motions (Jahnke et al., 2010). Moreover, Tai Chi is a kind of exercise that incorporates sitting, standing, posing and breathing. Practitioners have to regulate mind, body and breath in order to perform it well (Jahnke et al., 2010).

Tai Chi, which falls under Chinese Wushu which is the Chinese martial arts, was started back in the China. The development and growth of Tai Chi over more than three centuries have resulted in the emergence of five traditional styles known as Chen, Yang, Wǔ, Wú, and Sun (Guo et al., 2014). It was found out that the first person to design as well as to practice Tai Chi was by Master Chen Wangting in year

1600 to year 1680. Within that eight decades, he has emerged the formation of Chen style. Tai Chi was then further developed by Master Yang Luchan (1799 to 1872) and Master Yang Banhou (1837 to 1892) who developed the Yang style Tai Chi. After that, Tai Chi was developed into other style such as the unique Wǔ style, Wú style and Sun style varying the number of movements such as 24-form, 42-form, 48-form and 88-form (Guo et al., 2014).

Besides, Tai Chi is considered low impact and has included a series of features like balancing, strength, relaxation and even body alignment. Hence, it is suitable for people with different physical and health conditions as well as people from wide ranges of age (Jahnke et al., 2010). Tai Chi practice also does not require any superior facility or pricey equipment.

It is widely known that Tai Chi is a traditional systematic calisthenics exercise widely practiced in China. The classical Tai Chi consisted of complex forms (e.g. Chen style that consists of 108 postures) and it needs longer time to learn and practice (Zheng et al., 2015). In the process of development, many simplified Tai Chi styles have developed to accomate with different level of practitioners (e.g. the simplified Yang style) (Zheng et al., 2015) (see figure 2).

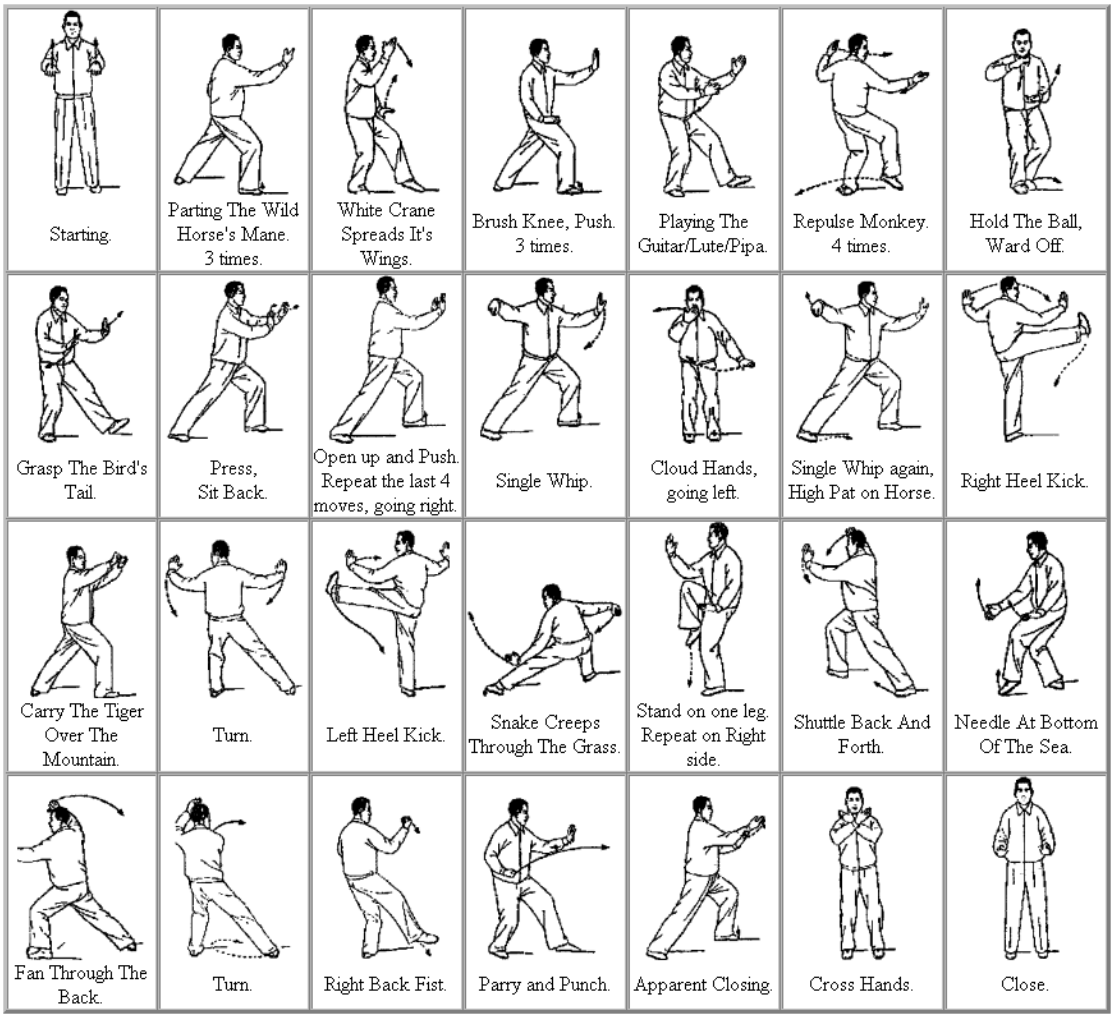

Figure 2.1 showed Simplified 24 form Tai Chi (Grush, 2013).

From the above, it is clear that Tai Chi includes standing and semi-squat positions (Lan et al., 2013). The high-squat posture and brief-training session are also suitable for deconditioned persons, such as patients who suffer from heart disease and even older adults (Lan et al., 2002). Some fundamentals of Tai Chi involve shifting body weight between left and right legs, knees flexing, straighten and extended head or trunk, body rotation, and asymmetrical diagonal limbs movements with bent knees. The exercise intensity of Tai Chi is flexible and adjustable by the height of the postures, duration of training session, and style of practice (Lan et al., 2002). Hence, both the exercise intensity and training period of Tai Chi are all

expected to have an effect on the improvements in one's aerobic capacity (Taylor-Piliae and Froelicher, 2004).

Several studies have suggested that Tai Chi may be effective in promoting physical and psychological health in the middle-aged and elderly populations (Verhagen et al., 2004; Xiong et al., 2015; Yeh et al., 2009). From the past, mind-body exercises were found to be effective in slowing down cognitive function declines but the studies were mostly among elderly (Lam et al., 2009; Yang et al., 2020; F. Zhang and Iwaki, 2019).

Tai Chi, the mind-body workout which incorporates low to moderate intensity with slow motions, deep breathing, and mental focus, has recently captured the interest of the general public as well as researchers in the related field. Tai Chi contains various components, including physical, cognitive, and social, that are thought to help general especially the elderly to preserve body health as well as their cognition . Zhang and colleagues evaluated the effects of different exercises which are swimming, jogging, dancing, and Tai Chi for 18 months on cognitive function and mood in older individuals (X. Zhang et al., 2014). They discovered that all of the physical intervention groups showed improvements on cognition and mood, but with the Tai Chi training group showed the most improvements compared to the other exercises.

A study by Yang et al (2020) found a significant difference for incongruent flankers were found only for the Tai Chi Chuan. (TCC) intervention group. They further suggested that Tai Chi intervention group showed shorter reaction time in incongruent flankers than the control group. With the help of functional near-infrared spectroscopy (fNIRS) in that study, researchers also suggested that the increase in

oxy-haemoglobin (oxy-Hb) in the prefrontal cortex among intervention group during the incongruent flankers after the TCC exercise intervention (Yang et al., 2020).

31 elderly participants were separated among Tai Chi-inspired exercises, dancing and step-based cognitive games 16 weeks (Adcock et al., 2020). Inhibition and working memory significantly improved after had Tai Chi-inspired exercises as intervention. A large scale study was conducted when 432 older adults from three Wisconsin cities were invited to do a 6-weeks TCC program (Chewning et al., 2020). Positive significant course effects for lower extremity strength, tandem balance, mobility and gait, confidence in balance and executive function among the elderly after the intervention. A significant improvement of detectability (which is a kind of measurement for attentiveness) was shown only in TCC practice groups after comparing with all exercise programs (Mayer *et al.*, 2019).

Another study by Ji et al (2017) had compared 84 healthy older adults between Tai Chi group (TG), the brisk walking group (BG) or the control group (CG) using Stroop task and Digit comparison task. The findings demonstrated that individuals in the TG and BG performed much better than the CG in terms of executive condition of cognitive tasks and fitness level. However, there was no significant difference in terms of reaction time and accuracy rate between the TG and BG in the inhibition and delay conditions of cognitive tasks and fitness. The TG had a faster reaction time when they were asked to do naming and executive conditions and was more accurate in the inhibition conditions than the BG.

An interesting findings by Kim *et al.* (2016) which their study included 64 adults who were asked to undergo 16 weeks of Tai Chi training to test on cognitive measure. By testing their visuospatial reasoning, mental-attentional activation (working memory), attentional inhibition and balance, they concluded that

improvements of all cognitive measures only showed among participants in the Chinese sample but only training group in non-Chinese sample.

In other word, Tai Chi could be an effective tool in the protection of cognitive ability. However, little studies have been conducted to investigate whether this kind of mind-body exercise can be recommended as an effective exercise or tool for improving the cognitive performances of young adults (Zheng et al., 2015). Hence, in this study, Tai Chi was selected to study its effects on the young adults' cognition performance.

2.4 Executive functions

Executive functions (EFs) which have the other names like executive control or some called them cognitive control. EFs are classified as a family of top-down mental processes. EFs play a role when one have to stay focus, to go on automatic or to rely on instinct. According to past studies, using EFs require more cognitive load as it is more stress-free to continue doing what one has been doing than to switch it (Diamond, 2013).

There are three general components under EFs which are inhibitory control, working memory (WM) and cognitive flexibility (J E et al., 2003). Inhibitory control normally enable one to selectively attend and focus on what to select. In the meanwhile, they were to suppress their attention to other distractors. WM is a more complex system that helps to maximise information storage and accommodate more complex cognitive utility (Baddeley, 2000). Cognitive flexibility are also called as set shifting, mental flexibility, or mental set shifting. The core components can be further built into more higher-order EFs like reasoning, problem solving, and planning (Collins and Koechlin, 2012). EFs are widely been studies as it is important

for both mental and physical health, specifically among cognitive, social, and psychological developments.

The EF that spark the researcher's interest in this study is inhibitory control. Reason being inhibitory control is the key for one to be able to control from own's thoughts to behaviour, and even attention or emotions. One needs inhibitory control in order to outweigh a strong internal predisposition or external lure, and instead do what's more proper or crucial. On the other hand, without inhibition, one might act impulse, decide thoughtlessly or act automatically (mostly due to conditioned response). We as human are organisms of habit and most of our behaviours are under the influence of environmental stimuli, but with the inhibition, we might be able to change and choose what we really want. Hence, inhibition is necessary for one to choose reaction and behaviour rather than acting without thinking.

In cognitive psychology, 'inhibitory control' is an umbrella term to portray voluntary control, or blocking of goal-irrelevant stimuli and behavioural responses (Diamond, 2013). There are two depending variables that have been investigated under the term of inhibitory control; which are response inhibition and attentional inhibition.

2.4.1 Response inhibition

Response inhibition refers to the process of stopping a motor response towards irrelevant stimuli (Aron et al., 2014). In other word, response inhibition is an ability to stop one's own response to distractions. For example, two children are paying close attention to a lesson, when there is a sudden ringing alarm in the hallway. One loses his attention while the other does not. The one that does not lose his attention is said to have a stronger response inhibition as he stops himself from being distracted to the noise outside. Response inhibition is also referred to

'behavioral inhibition,' 'motor inhibition,' 'prepotent response inhibition,' and 'attention restraint' (Diamond, 2013; Kane et al., 2016; Nigg, 2000, 2017).

From neurophysiological point of view, response inhibition involves a solitary circuit in the right ventral prefrontal cortical–basal ganglia–thalamic loop. Some studies suggested that response inhibition does not depend solely on a part of brain area only, but instead depends on communication across a network of connected brain areas. The brain cortex that involved in response inhibition are the inferior frontal gyrus (IFG and pre-supplementary motor area (shown in Figure 3). There are also areas that are close to the medial part of the brain. For example the subthalamic nucleus (shown in Figure 3) that is one of the deep brain structures. Areas mentioned above will communicate to one another through connections and this has been found out using neuroimaging technique named diffusion tensor imaging (DTI) (Madsen et al., 2010).

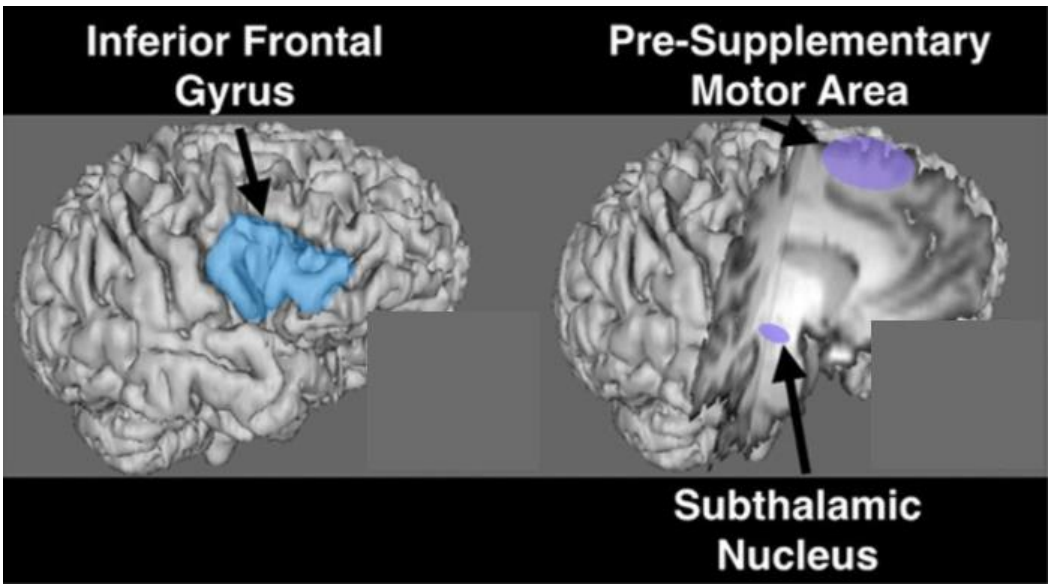

Figure 2.2 showed right IFG, pre-supplementary motor area, and subthalamic nucleus.

Apart from using neuroimaging technique, response inhibition has commonly been evaluated using non-selective stopping tasks, such as Stop Signal Task, go/no-

go task (see figure 2.3) and antisaccade tasks (will be explained in detail at the following section). During the tasks, participants are required to intermittently suppress a motor response when they are given presentation of a conditional stimulus or cue. Past researchers have utilized transcranial magnetic stimulation (TMS) to disrupt different parts of the brain cortex while participants doing the Stop Signal Task. They found that when TMS disrupt the right side of IFG, it slowed down the participant's ability to inhibit quickly (Chambers et al., 2006). In other word, they found out that right IFG could be one of the brain parts that was activated during response inhibition occur. Another study using functional magnetic resonance imaging (fMRI) found activations in brain parts like IFG and around the subthalamic nucleus (STN) when participants successfully stopped themselves (shown in figure 2.4) (F. Zhang and Iwaki, 2019).

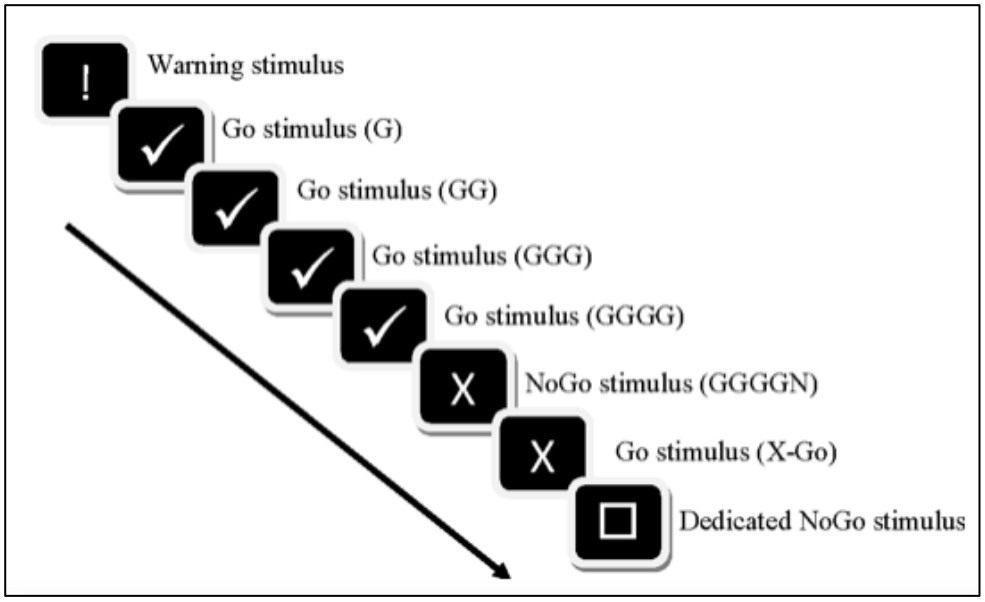

Figure 2.3 showed an example of go/no-go task.

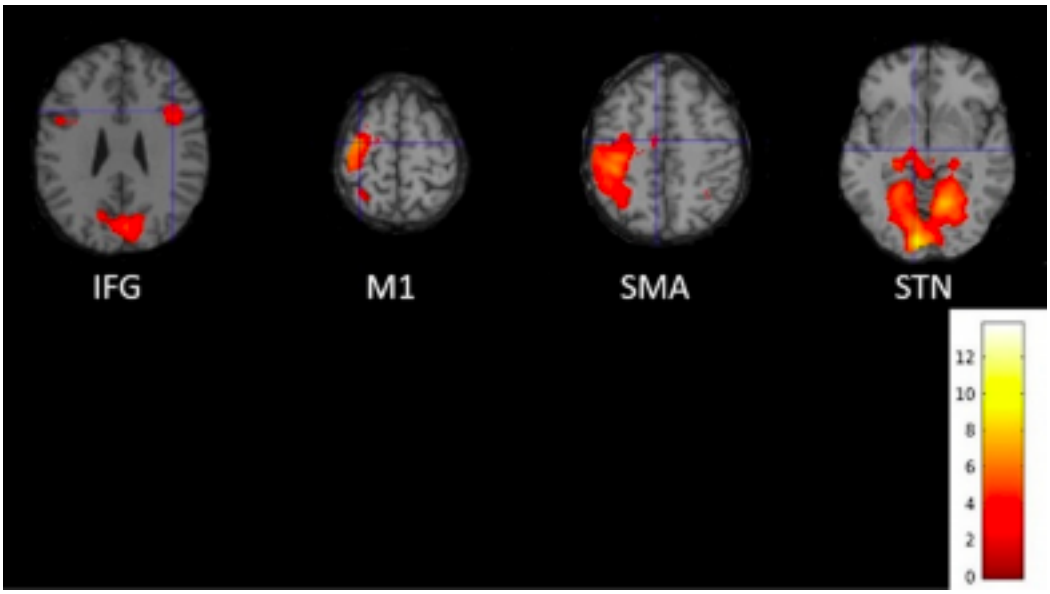

Figure 2.4 showed brain parts activation during the stop-signal using fMRI (F. Zhang and Iwaki, 2019).

2.4.2 Attentional inhibition

On the other hand, attentional inhibition is an ability to resist interference from stimuli in the external environment, or in other words, to ignore task-irrelevant distractors (Schrobsdorff et al., 2012). Attentional inhibition is also referred to as 'interference control,' 'interference suppression,' 'resistance to (distracter) interference,' and 'attention constraint' (Kane et al., 2016; Nigg, 2000; Wiebe et al., 2008). Furthermore, attentional inhibition has been investigated using visual matching tasks that need participants to decide whether target and comparison stimuli are the identical or different whilst ignoring task-irrelevant distracters (Nigg, 2017; Stahl et al., 2014).

Past researchers are interested in the neuropsychological mechanisms of attention and ignoring irrelevant information (Schrobsdorff et al., 2012). Since attention is normally guided by processes in the prefrontal cortex and the actuality is that prefrontal feedback is usually provided by inhibitory signals, it seems likely that inhibition plays a key role in the effects of selective attention.

2.5 Tasks

In this section, both Antisaccade task and Visual Search Task will be discussed. Antisaccade task was selected to study the response inhibition while Visual Search Task was chosen to determine the attentional inhibition of the participants.

2.5.1 Antisaccade task

Oculomotor recordings signify their expertise in the field of studying about inhibitory control. One of the popular tasks, which is the antisaccade task embodies this approach. When doing the normal version of the task, participants are required to resist their reflexive eye movements towards the new appearing peripheral target but instead to move their eyes to the opposite direction (Magnusdottir et al., 2019).

At the beginning of the task, participants needed to view the central part of a computer screen that act as a fixation point. Then, a target showed up in either left or in the right periphery. Participants are asked not to look at the target but towards the opposite direction. Participant who shows more correct antisaccade response (that is to look at the opposite side of the target) indexes a better inhibition (Magnusdottir et al., 2019).

There are several reasons for oculomotor measures like antisaccade task to be an intriguing tool for inhibitory functions evaluation. One of the reasons is the neural underlying both the visual cue effects and the visual guidance systems are fairly well recognized (Coe and Munoz, 2017). Besides, the overt oculomotor response on inhibitory control might be unaffected by additional problems in motor and language development when participants have disorders like ADHD that can affect many laboratory tasks.

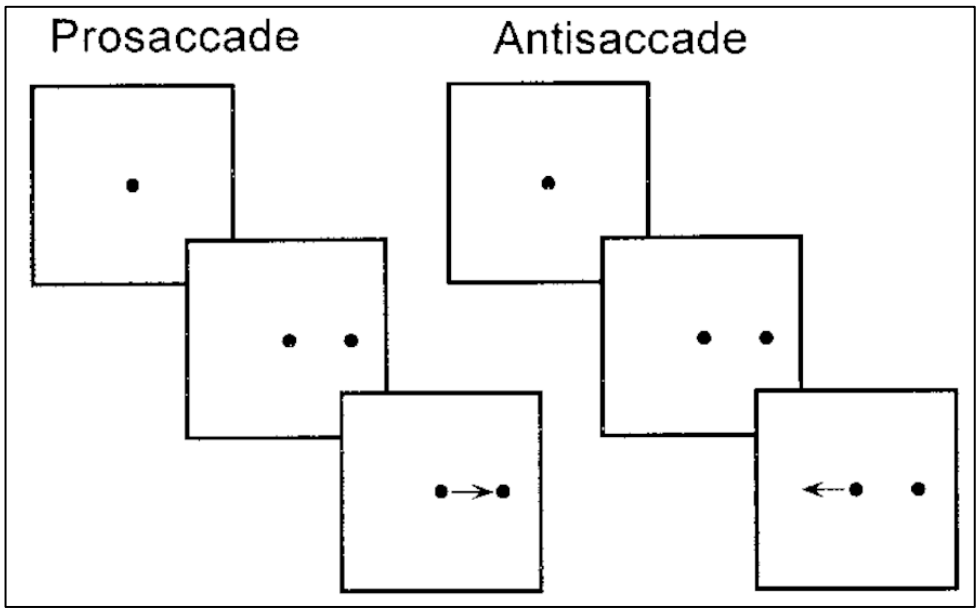

Figure 2.5 shows an example of prosaccade and antisaccade conditions in antisaccade task.

In congruent trials, which is following the sign of cues, allows human brain to have stimulus recognition and allow response production to happen automatically. In incongruent trials, which is to look away from the sign of cues. However, there is a mismatch between congruent and incongruent inputs and response inclinations, which compete for further processing. Incongruent trials will often require longer mean reaction times than congruent trials. The 'interference effect' refers to the additional time which is vital to resolve the conflict raised between conflicting input representations and response inclinations (Fan et al., 2000).

2.5.2 Visual search task

There was an idea anticipated by (Treisman and Schmidt, 1982) which study about the feature integration theory of attention. This theory meticulously describes the importance of role of attention in visual object recognition. The central idea of the theory is that visual perception is divided by two stages, which are pre-attentive and cross dimensional integration. During pre-attentive stage, each features are separable and are processed independently in the brain. On the second stage, which is

cross dimensional integration, is to combine fundamental features to form a togetherness that is widely known as feature integration.

In this study, participants were required to look for a coloured letter, which is the feature search. If participants saw same coloured letter, participants have to press "space" on the keyboard. Participants were requested to ignore distractors such as the different coloured letter and letter with different orientation.

To study if Tai Chi can improve the response inhibition and attentional inhibition among young healthy adults, current study would be utilizing an eye-tracker. As researcher would like to understand their eye movements through assessing cognitive tasks to obtain a richer data. Eye movements are suggested to be one of the most natural sources to understand human behavior as the goal is to extract relevance feedback from gaze (Moorman and Ram, 1994). The eye-mind hypothesis suggested earlier on by Carpenter in 1980 has stated that there is a tight relationship between human gaze and their attention, provided with the condition that the visual environment in front of subjects' eyes are relevant to the task that researchers want to study (Moorman and Ram, 1994). In this study, eye tracker was used to collect information about the eye fixations within a specific area on a computer monitor in front of subjects. Besides, first fixation latency, that is the time needed for participants to look for the correct target was collected as well.

2.6 Tai Chi, response inhibition and attentional inhibition

In the current study, Tai Chi acted as an intervention to study its effect on both response inhibition and attentional inhibition (see Figure 2.6 for the conceptual framework of this study). The response inhibition and attentional inhibition were measured in terms of the accuracy rate and reaction time with the help of eye tracker.

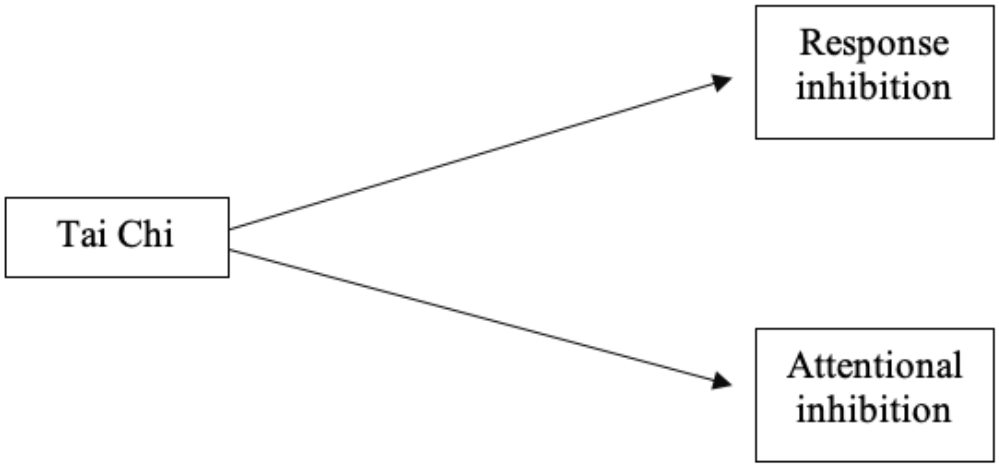

Figure 2.6. Conceptual framework of the current study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter included the research methods used in this study. It presents research design, study area as well as population in this study. Population of this study is further explained using a list of subject inclusion and exclusion criteria. Calculation of the sample size, sampling method and subject recruitment are also reviewed. Later, all the research tools used and methods to collect data are discussed in this chapter. This chapter has included different operational definitions as well as the entire flowchart of study. This chapter ends by discussing the data analysis of the study.

3.2 Research design and method

This study is an interventional study in which the data collection was administered at two-time points which are the pre intervention and post intervention. Interventional study design is the study where researchers collect and compare the data pre and post intervention (Thiese, 2014). The intervention in this study was the 16 sessions of Yang-styled Tai Chi. It was a within-subjects design study as the subjects were tested on their attentional inhibition and response inhibition before and after the intervention. Control group was not included due to the data collected was compared with the participants' initial score to have the same baseline during data collection. After the initial process of screening, participants underwent the Tai Chi intervention for four times every week for four weeks continuously.

3.3 Study area

The study was conducted at University Sains Malaysia, Kubang Kerian, Kelantan in Malaysia. The area was chosen as the population of interest was located at there and the eye tracker was available only at the place.

3.4 Reference and source population

The study population in this study is the population from School of dental and Health Sciences in University Sains Malaysia which located in Kubang Kerian campus.

3.5 Participants criteria

3.5.1 Inclusion Criteria

1. Participants must be between 18 – 30 years old
2. Participants must be from School of Dental and Health Sciences as participants from other department might feel obliged and pressured to join the study since the supervisors of this study are teaching them which might raise ethical issue
3. Participants must be willing to undergo Tai Chi training
4. Participants must be healthy from all aspects (no history of mental or neurological history)
5. Participants must have normal or corrected to normal vision

3.5.2 Exclusion Criteria

1. Without informed consent form

2. Attended regular practices of Tai chi or other mind-body based exercises (eg, yoga, martial arts, dances etc.) in the past 6 months to avoid confounding with the Tai Chi intervention.