THE EFFECT OF MINDFULNESS MOVEMENT THERAPY ON ARM AND HAND FUNCTION IN PEOPLE WITH AND WITHOUT STROKE

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ABSTRACT

Upper extremity motor deficit is a big issue in patients with stroke. Mindfulness meditation may have potential to improve arm and hand function in stroke patients. However, there is no mindfulness programme specifically concerned with motor performance. Therefore, this thesis proposed a new protocol of a mindfulness movement therapy programme (MMTP) for improving arm and hand function in patients with stroke.

There were 4 phases to this thesis, phase I; a systematic review of meditation for motor function in patients with stroke, phase II; a preliminary study in older adults, phase III; a randomised single-blind controlled trial in healthy older adults, and phase IV; a preliminary study in patients with stroke. In phase I, 13 studies were included for qualitative synthesis but no studies focused on the primary outcome of motor function. In phase II, MMTP improved motor performance speed of the upper limbs for both hands, especially in the trained upper limb ($p=0.008$) and affected mood ($p=0.033$) accompanied by improved sensorimotor and attentional functioning in the brain. In phase III, MMTP increased nerve conduction velocity ($p=0.018$) with no changes in the active control group. Moreover, motor performance speed improved in the trained upper limb ($p<0.0001$). In the last phase, MMTP improved spasticity of the elbow flexor ($p=0.025$) and finger flexors ($p=0.034$), mindfulness ($p=0.027$), and quality of life ($p=0.043$).

It was concluded that MMTP might have the potential to add to the standard rehabilitation programme for improving motor performance of the upper limb in people with and without stroke. While this thesis provides promising evidence, larger clinical trials are needed to confirm the effects of MMTP as a new intervention for improving arm and hand function in patients with stroke.

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CONTENTS

Page Number

Page Number

Page Number

Page Number

Page Number

Page Number

Page Number

Page Number

Page Number

Page Number

LIST OF TABLES

LIST OF FIGURES

Page Number

ACRONYMS AND ABBREVIATIONS

AC	Active control
ACC	Anterior cingulate cortex
ADP	Aphasia Diagnostic Profiles
AMMP	Aphasia Mindfulness Meditation Programme
ANS	Autonomic nervous system
APT-II	Attention Process Training II Questionnaire
ARAT	Action Reseatch Arm Test
BAI	Beck Anxiety Inventory
BBS	Berg Balance Scale
BDAE	Boston Diagnosis Aphasia Examination
BDI	Beck Depression Inventory
BDI-II	Beck Depression Inventory, Revised
CASP-19	Older People's Quality of Life; Control, Autonomy, Satisfaction, Pleasure-19 items
CAT	Comprehensive Aphasia Test
CBF	Cerebral blood flow

ACRONYMS AND ABBREVIATIONS

CBT	Cognitive Behavioural Therapy
CD	Compact disc
CLQT	Cognitive Linguistic Quick Test
CMCT	Central motor conduction time
CPRS	Comprehensive Psychopathological Rating Scale
CPT-II	Connor's Continuous Performance Task-II
CRSD-ANT	Centre for Research on Safe Driving-Attention Network Test
D1F	PNF pattern of shoulder flexion-abduction-external rotation
D1E	PNF pattern of shoulder extension-adduction-internal rotation
D2F	PNF pattern of shoulder flexion-adduction-external rotation
D2E	PNF pattern of shoulder extension-abduction-internal rotation
DSR	Distiller Sysematic Review
EEG	Electroencephalography
ERP	Event-related Potential
FA	Focused attention meditation
FAC	Functional Ambulation Classification Scale

ACRONYMS AND ABBREVIATIONS

FDI	First dorsal interosseous
FFMQ	Five Facet Mindfulness Questionnaire
FMA-UE	Fugl-Meyer Assessment Upper Extremity
FMI	Freiburg Mindfulness Inventory
fMRI	Functional magnetic resonance imaging
HADS	Hospital Anxiety and Depression Scale
HRV	Heart Rate Variability
ICF	Intracortical facilitation
ICI	Intracortical inhibition
ICP	Intracranial pressure
I-PANAS-SF	International Positive and Negative Affect Schedule Short Form
JHFT	Jebsen Hand Function Test
M1	Primary motor cortex
MAAS	Mindful Attention Awareness Scale
MAS	Modified Ashworth Scale

ACRONYMS AND ABBREVIATIONS

MBCT	Mindfulness-based cognitive therapy
MBI	Mindfulness-based intervention
MBSR	Mindfulness-based stress reduction
MCA	Middle cerebral artery
MCC	Mid-cingulate cortex
MEP	Motor-evoked potential
MeSH	Medical subject headings
MFS	Mental Fatigue Scale
MM	Mindfulness meditation programme
MMSE-Thai 2002	Thai version of the Mini-Mental State Examination
MMTP	Mindfulness movement therapy programme
MT	Motor threshold
OANB	Object and Action Naming Battery
OM	Open monitoring meditation
PHLMS-TH	Philadelphia Mindfulness Scale Thai version
PNF	Proprioceptive neuromuscular facilitation

ACRONYMS AND ABBREVIATIONS

POMS-SF	Profile of Mood States-Short Form
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
PROSPERO	International Prospective Register of Systematic Reviews
PSQI	Pittsburgh Sleep Quality Index
PSS	Perceived Stress Scale
RCT	Randomized controlled trial
RMT	Resting motor threshold
RSAP	Rating Scale for Attentional Problems
RTT	Revised Token Test
SCS	Self-Compassion Scale
SF-36	Short-Form 36 General Health Survey
SGCQ	Shortened General Comfort Questionnaire
SIS	Stroke Impact Scale
SQfMF	Self-Assessment Questionnaire for Mental Fatigue
SPSS	Statistical Package for the Social Sciences

ACRONYMS AND ABBREVIATIONS

SS-QOL	Stroke Specific Quality of Life Scale
STAI	State-Trait Anxiety Inventory
TBI	Traumatic brain injury
tDCS	Transcranial direct current stimulation
TGDS	Thai Geriatric Depression Scale
TIA	Transient ischaemic attack
TMS	Transcranial magnetic stimulation
TMT	Trail Making Test
WHOQoL-BREF	World Health Organization Quality of Life Instruments
10MWT	10-Meter Walk Test

CHAPTER ONE

INTRODUCTION

1.1 Introduction to thesis

Stroke or cerebrovascular disease is the second most common cause of mortality around the globe and leads to long-term disability (1-5). Upper limb motor impairment is a large problem following a stroke caused as a result of poor hand function leading to difficulty in performing activities of daily living such as self-care, work, or leisure (6-9). Consequently, stroke survivors may also be anxious or depressed, resulting in a lack of motivation to engage in physical activities and rehabilitation. In addition, they might develop secondary complications in the upper extremity, for instance, shoulder pain, shoulder subluxation, or shoulder-hand syndrome (10-13). These problems also hinder the recovery of arm and hand function and may result in a poor quality of life (10, 11). However, intervention approaches are still controversial in respect of their effectiveness in the management of upper limb problems following a stroke (14).

In the last 50 years, meditation has stimulated interest in researchers and health professionals, and it is acknowledged that mindfulness meditation may have several positive benefits in a variety of health conditions including stroke (15, 16). Evidence confirms that mindfulness meditation programmes should be merged into standard rehabilitation programmes for improving some problems in patients with stroke such as anxiety, depression, and mental fatigue (17). Moreover, systematic reviews demonstrate that both short-term and long-term meditation could induce both functional and structural neuroplasticity within the brain areas linked to control of movement, for instance, the prefrontal cortex, hippocampus, cerebellum, and corticospinal tract (18-23).

However, no specific mindfulness-based approaches have been developed for improving motor deficits. Therefore, a new protocol of mindfulness movement therapy programme (MMTP) for improving arm and hand function in patients with stroke is proposed in this thesis. The feasibility of using MMTP was investigated and the effects on motor performance and cortical motor activities in older adults within different contexts and cultures were explored. After that, the feasibility of a MMTP was examined and the effects on arm and hand function in patients with stroke investigated.

Therefore, this thesis presents three experimental studies in people with and without stroke. In addition a chapter on the background and literature relevant to this thesis is included, consisting of four parts: 1) a systematic review of meditation on motor function in patients with stroke, 2) a preliminary study of MMTP on the motor performance of the upper limbs in an older United Kingdom-based population 3) a randomized single-blind controlled trial of MMTP on the motor performance of the upper limbs and motor cortical plasticity in healthy Asian older adults, and 4) a preliminary study of MMTP on arm and hand function in patients with stroke.

1.2 Aims and hypotheses

1.2.1 Part one: a systematic review of meditation for motor function in patients with stroke

1.2.1.1 Background

Prior to the do research about mindfulness meditation programme in stroke patients, it was necessary to conduct a systematic review to explore the effects of meditation on motor function in patients with stroke to acquire information for developing and researching the effect of MMTP on stroke patients.

1.2.1.2 Aim of a systematic review

A systematic review explored the effects of meditation on motor function in patients with stroke and how patients with stroke might benefit from meditation.

1.2.2 Part two: a preliminary study of the effect of a mindfulness movement therapy programme on the motor performance of the upper limbs in older adults

1.2.2.1 Background

We proposed a new protocol of MMTP for improving arm and hand function in patients following a stroke. It was necessary to test this programme in healthy people before applying it to patients with a stroke. An elderly population was selected to test the protocol due to stroke having a high incidence in the elderly population (1) and the histology of the brain should be the same allowing for comparison of any changes noted.

1.2.2.2 Aim of the study

The study investigated the feasibility and the effects of a MMTP on the motor performance of the upper limbs in the United Kingdom older population compared with an active and a passive control group.

1.2.2.3 Hypotheses for the study

A MMTP would improve the motor performance of the upper limb, cortical sensorimotor activities, attentional performance within the sensorimotor system, mindfulness, mood, perceived stress, and quality of life in older individuals after completing eight weeks of the programme.

1.2.3 Part three: a randomised single-blind controlled trial of the effect of a mindfulness movement therapy programme on the motor performance of the upper limbs and motor cortical plasticity in healthy older adults

1.2.3.1 Background

It was necessary to confirm the effects of MMTP on motor performance of the upper limbs and cortical motor plasticity, this time as measured by transcranial magnetic stimulation (TMS) in healthy older people, by improving the methodology and increasing the sample size. A blind assessor was used in this study to eliminate bias. Moreover, the MMTP was evaluated in a healthy Asian older population to endorse that MMTP has positive effects in all context and culture.

1.2.3.2 Aim of the study

This study investigated the effects of a MMTP on the motor performance of the upper limbs and motor cortical plasticity in a healthy Asian older population compared with an active control group (AC).

1.2.3.3 Hypotheses for the study

A MMTP would improve the motor performance of the upper limbs, cortical motor plasticity, mindfulness, anxiety and depression, perceived stress, and quality of life in healthy older adults after completing eight weeks of the programme.

1.2.4 Part four: a preliminary study of the effect of a mindfulness movement therapy programme on arm and hand function in patients with stroke

1.2.4.1 Background

Finally, a MMTP was applied to investigate the effects on arm and hand function in patients with stroke. The MMTP was delivered to stroke patients in an individual format and with face to face interaction for monitoring the safety and to adjust the intensity of the programme to suit each patient during each visit.

1.2.4.2 Aim of the study

The study examined the feasibility and the effects of a MMTP on arm and hand function in patients with stroke compared with the test-retest effects of a control period.

1.2.4.3 Hypotheses for the study

MMTP combined with the patients' usual rehabilitation programme could improve arm and hand function on the affected side, cortical motor plasticity, impairment of the affected upper limb, spasticity, mindfulness, anxiety, depression and quality of life in patients with stroke after completing eight weeks of the programme.

CHAPTER TWO

BACKGROUND AND LITERATURE REVIEW

2.1 Chapter overview

In this chapter, information and research related to mindfulness meditation and stroke are presented. It commences with an overview of stroke - incidence, burden, signs and symptoms, aspects of middle cerebral artery syndrome, upper extremity problems, and intervention in upper limb problems. Then, definitions of meditation, including Vipassana meditation, Zen meditation, and mindfulness-based intervention (MBI) including mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT) are provided. Published data on the influence of meditation on neural plasticity in patients with stroke are summarised, followed by an explanation of the concept of MMTP.

2.2 Stroke

2.2.1 Incidence of stroke

Stroke is the second most common cause of mortality worldwide and is the main cause of long-term neurological disability, especially during middle age and old age (1-5, 24, 25). The yearly first-time incidence of stroke is 17 million globally, with 6.7 million resulting in deaths (26). The prevalence of stroke survivors worldwide was approximately 62 million in 2005 and is expected to reach 77 million in 2030 (27). In the European Union, more than 1 million people suffer from stroke every year, and in Great Britain, approximately 150,000 people have a stroke each year (5, 25). In the United States, an estimated 6.8 million people have had a stroke which accounts for

2.8 per cent of the total population. It affects approximately 795,000 people each year including approximately 610,000 first time events, and 185,000 recurrent attacks (28).

2.2.2 Burden of stroke

The cost of care for patients with stroke is increasing worldwide for both direct care cost such as health and social care and indirect care costs such as productivity losses due to care, disability, and death. In the United States, the total care costs, both directly and indirectly for stroke patients was approximately 53.6 billion US dollars in 2004 and increased to 65.5 billion US dollars in 2008 (29). In the United Kingdom, the total cost of care for stroke patients is approximately 9 billion pounds per year. Direct care costs are around 4.38 billion pounds per year. The costs of informal care are estimated at 2.42 billion pounds. Indirect costs accounted for approximately 1.33 billion pounds. The average cost of care for stroke patients accounted for 23,315 pounds per capita. In the 27 European countries, the total estimated cost of caring for stroke patients was around 27 billion euros with direct costs of 18.5 billion euros, representing a 68.5 per cent of the total care cost and indirect costs of 8.5 billion euros, representing 31.5 per cent of the total care cost. There was an additional of 11.1 billion euros of informal costs (29, 30).

2.2.3 Signs and symptoms of stroke

Stroke is one of the largest causes of disability (12). More than the half of stroke survivors have a residual impairment (12) which may turn into a long-term neurological disability (2, 3, 5, 24, 25, 31). It has an influence on both physical and non-physical functions depending on the site of lesion (12, 30).

Physical impairments are common in patients with stroke, including upper extremity weakness, lower extremity weakness, facial weakness, sensory loss, dysphagia, visual problems, reduced bladder control or reduced bowel control (12). Stroke survivors usually suffer from impaired motor function of the face, upper limb, lower limb and trunk on one side of the body, called hemiplegia or hemiparesis (31-33). For these reasons, the patient is limited in functional activities such as hand function, balance, walking, basic and instrumental activities of everyday living (12, 34).

Non-physical impairments are also found in patients with stroke, including alterations of mood, cognition, perception, mental fatigue, anxiety and depression (12, 34). Fatigue is a common symptom frequently reported following a stroke. The percentage of stroke survivors that have reported post-stroke fatigue is in the range of 30 to 70 per cent (from mild to severe). The impact of stroke-related fatigue can continue for years after a stroke. It can affect every domain of activities of daily living and result in difficulty for the patient to return to work and to participate in community activities (35, 36). When patients are faced with a life-changing crisis such as stroke, negative thoughts are a frequent phenomenon. Negative thoughts combined with physical impairments can cause depression (37). Empirical evidence indicates that one-third of stroke survivors struggle with depression and anxiety, these symptoms can continue for several years after the first stroke and are related to poor neurological recovery and lower quality of life (3, 12, 34, 38).

2.2.4 Middle cerebral artery syndrome

The development and presentation of a stroke varies depending upon the cause; the middle cerebral artery (MCA) is the affected pathological site of 87 per cent of all stroke survivors (24, 39, 40). The MCA supplies the entire lateral aspect of a cerebral hemisphere, including the primary motor and sensory areas of the face, throat, hand and arm (24). As a result, those with hemiplegia have a more severe impairment of the face and upper extremity, with relative sparing of the lower extremity (24, 41, 42) and upper limb weakness is present in 77 per cent and lower limb weakness in 72 per cent of all stroke survivors (12).

2.2.5 Upper extremity problems in patients with stroke

Upper limb motor deficits in patients with strokes are a major problem as approximately 85 per cent of stroke survivors are faced with one sided paralysis with an immediate impairment of an upper limb. Only 5 to 20 per cent of stroke survivors with initial upper limb impairment obtain full recovery of their upper limb function and 55 to 75 per cent of stroke survivors still have problems with hand and arm function 3 to 6 months after the initial stroke (6-8). Furthermore, four in five stroke survivors are discharged from rehabilitation centres with limited arm function (43). These patients have more difficulties in daily activities such as personal hygiene, dressing, and eating (9). This affects the psychological state of patients (10, 11) with about 33 per cent of stroke survivors experiencing depression (12, 44) and 20 per cent experiencing anxiety at some point after stroke (13). Thus, depression and anxiety are important sequelae of stroke that can hinder recovery (38). Stroke survivors tend to avoid the use of the affected upper limb wherever possible. For this reason, functional recovery of the affected upper limb is often slow (45) and contributes to secondary complications like inferior shoulder subluxation with an incidence of 7 to 81 per cent, shoulder pain with an incidence of 16 to 72 per cent, and shoulder-hand syndrome with an incidence of 12 to 27 per cent. These complications further hinder the recovery of the affected hand and arm function (10, 11).

2.2.6 Intervention in upper extremity problems

Although stroke patients may receive immediate multidisciplinary rehabilitation, only 5 to 20 per cent of patients recover completely (43). Thus, the upper limb rehabilitation programme is a key component for improving arm and hand function in patients with stroke (14, 46). Systematic reviews of optimisation techniques to rehabilitate stroke patients for the recovery of the upper limb function identify that upper limb rehabilitation in patients with stroke is related to several different approaches including bilateral arm training, biofeedback, brain stimulation (transcranial direct current stimulation; tDCS, transcranial magnetic stimulation; TMS), complementary interventions, electrical stimulation/ functional electrical stimulation, mental practice, mirror therapy, music therapy, electromechanical and robot assistance, repetitive task training, task-specific training, hands-on therapy interventions (manual therapy techniques), Bobath approach, sensory intervention, strength training, stretching and positioning, virtual reality training and constraint-induced movement therapy (14, 46, 47). Although there are several upper limb intervention approaches, the evidence is still insufficient to demonstrate which ones are the most effective to improve arm and hand function and the therapist still needs to select and provide these treatments based on individual assessment and personal experience (14).

2.3 Meditation

2.3.1 Definition of meditation

In the last 50 years, the practice of meditation has become widely popular around the globe (15). There are hundreds of millions of practitioners around the world and 18 million Americans regularly meditate (15, 48). Meditation is the first form of mind-body therapy and has been adapted for complementary interventions in a variety of health conditions. Both secular or traditional meditation has provoked interest and acceptance from researchers, clinicians, and the general public, acknowledging that meditation is very useful for promoting medical knowledge (15, 16).

Meditation is a cognitive, spiritual, and mind-body practice that also acts as mental training for cultivating concentration and mindfulness (20, 49-52). The main goal of mindfulness is to pay total attention to the present moment by accepting current experience without reaction and judgement (18, 50, 51, 53, 54). Meditation has been practised for more than 5,000 years in some countries of the world. "Samadhi" is the term that is most often used for meditation in the original language of Buddhism. An appropriate translation of this word from Sanskrit or Pali is "placing (dha) the mind (sam) upon an object". Thus, meditation is a practice to focus the mind to a single point upon a particular object (55). In the past, the goal of spirituality or religion was integrated into all forms of meditation, and the ultimate goal of meditation was to develop spiritual enlightenment, awakening or transcendental experience (15).

2.3.2 Type of meditation

There are two main broad categories of meditation practices: Mantra meditation and mindfulness meditation. Mantra meditation comprises the Transcendental Meditation® technique, relaxation response and clinically standardised meditation.

Mindfulness meditation consists of Vipassana, Zen Buddhist meditation and MBI including MBSR and MBCT (15). Meditation techniques can further be categorised into (1) focused attention meditation (FA) and (2) open monitoring meditation (OM) or open observing. The central concept of FA is the concentration of mind, directing and sustaining attention on a chosen object, such as mindfulness of breathing, scriptural passage, mantra meditation or religious pictures. A typical example is Shamatha as a single pointed, focusing, pacifying and calming meditation technique. OM or open observing does not have an explicit focus on objects but involves non- reactive monitoring of the content of experience as time goes by. Typical examples of OM techniques are Zen meditation and Theravada Vipassana. While Zen meditation is characterised by meta- attention, Vipassana is a form of meditation that includes any meditation technique that cultivates insight including contemplation, introspection, analytic meditation and observations about the experience (18, 52, 54). Those of meditation techniques involve mindfulness that is an essential tool for empowering the ability for reflection (54).

2.3.3 Mindfulness meditation

Recently, mindfulness meditation has received increasing attention and stands out in subgroups of meditative practices (51). Mindfulness is derived from Buddhism and is based on the contemplative traditions of the East (3, 34). It is a translation of the Pali Vipassana that “sees through” (passana) “various” aspects (vi) (56). Mindfulness meditation provides a means to practise mindfulness. Awareness of the present moment- by- moment experience as well as nonjudgmental awareness and to keep an open mind towards all stimulations are the main characteristics (3, 34, 56). Therefore, mindfulness meditation must be accompanied by attention, intention, acceptance, present awareness, and non-judgement. These elements must be present in the moment in order to experience mindfulness (57). Mindfulness meditation practices are included in the traditional Vipassana, Zen meditation and mindfulness-based techniques (15).

2.3.3.1 Vipassana meditation

Vipassana meditation originated in India more than 2500 years ago and is the oldest of traditional Buddhist practice focusing on present-moment sensory awareness. Vipassana meditation primarily uses the silent observation of the breath to focus momentary awareness. Secondary points of awareness are mentally labelled as they were recognised followed by a return to breath observation. A central aspect of Vipassana meditation is to bring full attention to the present moment while the experience is accepted as it is without any judgment. It is a moment-by-moment experience with purposeful attention. Vipassana meditation tries to understand the "three characteristics of nature": impermanence (anicca), sufferings (dhuka) and non-existence (anatta). Compared to Zen meditation it is reported to be easier to practise, to be more enjoyable and more calming (15, 18, 53).

2.3.3.2 Zen meditation

Zen meditation originated in India several thousand years ago and spread to China under the influence of Confucianism and Taoism, and China propagated it to Japan in 1191. A specific characteristic of Zen is the understanding that a problem cannot be solved by logic thinking but problem-solving needs intuitive powers (koan). Its most important principle is the harmony of body, mind and breath, but posture also is very important. In traditional forms of Zen meditation, practitioners sit on a cushion in full-lotus or half-lotus position. While the upper and lower molar teeth contact together gently, the tongue should touch the upper jaw. Practitioner should be half blindfolded and stare at a point on the floor about three feet in front of them. There are many patterns of breathing in Zen meditation. For example, exhaling completely through the mouth and relaxing the lower abdomen, then inhaling through the nose and chest to the abdomen and repeating this breathing pattern about four to ten times. This is followed by then inhaling and exhaling through the nose only, with smooth and long breaths. The most advanced pattern of Zen meditation is "shikantaza", where practitioners should breathe slowly about three to six breaths per minute. Practitioners pay attention to breathing count in one of three ways: counting both inhalations and exhalations, counting only inhalations, or counting only exhalations (15, 58).

2.3.4 Mindfulness-based intervention

This has been designed and adapted from the original principles of mindfulness into standardised programmes for improving physical and mental health, including MBSR and MBCT (51). It should be emphasised that MBI is fundamentally different from relaxation techniques in which reaching a meditative state is the explicit goal. Instead, the aim of the mindfulness programme is the awareness of what is happening in the present moment, whether it is emotion, feeling, thought or maybe a deep relaxation that can happen through this process. Therefore, a mindfulness programme is for improving the "being mode" by providing a basic understanding of "non-striving" and "non-doing" (34). The standard mindfulness practice is a group-based programme that takes about 8 to 10 weeks, 2 hours per week with daily homework and a one-day retreat. The evidence confirms that MBSR and MBCT programmes are effective in treating anxiety and depression in both patient populations and the general population (59). After completion of the 8-week programme, practitioners can practice continuously on their own or in the form of community-based locations with support of a peer or rehabilitation team. In addition, MBI programmes are not expensive, require a minimal number of tools or other resources, and can take place in any location which can hold approximately ten people (27).

2.3.4.1 Mindfulness-based stress reduction

MBSR is a standardised meditation programme created by Jon Kabat-Zinn at the University of Massachusetts Medical Center in 1979, which combines Buddhist mindfulness meditation with clinical practice and ideas from modern psychology. The main characteristic of MBSR is the cultivation of mindfulness, a principle that is the foundation of Buddhism. It consists of the development of attention, of awareness without judgment, openness, curiosity, and the adoption of the present experience both internal and external. MBSR consists of three components: a body scan, sitting meditation, and Hatha yoga. Body scan is gradually sweeping attention through the entire body from the feet to the head, paying attention to every sensation or feeling in each body part and using periodic breathing awareness in between periods of body scan. Sitting meditation is mindful attention to breathing, on the rising and falling of the abdomen or other bodily perceptions, and of constant awareness without judgment of cognition and the flows of ideas and disturbances that constantly enter the mind. Hatha yoga is designed for strengthening and relaxing the musculoskeletal system by breathing exercise, simple stretching and posture. The MBSR programme consists of a range of treatments and requires practising at home for minimum 45 minutes a day, six days a week for eight weeks. This programme has been used to treat many patients with chronic pain, stress and anxiety, sleep disorders, cancer, heart disease, hypertension, and stroke (57, 60, 61).

2.3.4.2 Mindfulness-based cognitive therapy

MBCT was developed from MBSR by Zindel Segal, Mark Williams and John Teasdale in the 1990s. This programme consists of the body scan, sitting meditation and integrated cognitive behavioural therapy (CBT). It was designed specifically for the treatment of recurrent depressive disorders (57, 62, 63). The main principle of the MBCT programme is awareness, acceptance, and letting go (34). The original purpose of the MBCT programme was to help people with depression modify the relationship of thoughts, feelings and body sensations that are leading to the occurrence of relapse; and causing a change in the depressed person's understanding at a deep level (15). The core skills that are developed through the MBCT programme are to recognise and let go of the obsession with negative thoughts or ideas that are wrong. The MBCT guides practitioners to realise the thoughts, positive or negative, and to identify that it is associated with emotional or physical responses. As a result, individuals become mindful of "being" and "accepting", which produces the opportunity for the individuals to break the habit of thought rumination patterns (34). The programme is taught in an 8-week class format with one 2-hour session per week plus a retreat day held at week 6 or 7 (15, 57, 62).

2.4 Meditation and neural plasticity

At present, clinical research includes a number of studies investigating the effectiveness of meditation on neurological changes (64). Based on empirical evidence, it has been found that meditation affects the structure and function of the brain (18, 19). Within the cerebral cortex, subcortical white and grey matter, cerebellum and brain stem neuroimaging studies have shown that meditation stimulates lasting changes in brain activity, which indicates that meditation is able to affect brain networks on a large scale (19, 20, 52, 53, 65). Moreover, some researchers reported that meditators have a higher thickness of corpus callosum, enhance the networking inside the brain and the connection of nerve fibre tracts to the brain (20, 52, 53, 65).

Neural plasticity depends on the duration of meditation practice, divided into short and long-term meditation (21). Short-term meditation ranges between 5 and 60 hours of actual meditation practice, while long-term training lasts several years (19). A recent meta-analysis confirmed that long-term meditators show structural alterations in eight brain areas including the frontopolar cortex, which may improve meta-awareness after meditation; the sensory cortices and the insula, regions that are related to exteroceptive and interoceptive body awareness; the hippocampus, which processes memory to consolidate and to reconsolidate; the anterior cingulate cortex (ACC), the mid-cingulate cortex and the orbitofrontal cortex, areas involved in the regulation of self-awareness and emotions; and the superior longitudinal fasciculus and the corpus callosum, regions related to intra- and interhemispheric communication (21). Short-term meditation can induce similar brain changes as long-term practice (21). Gotink et al. (2016) demonstrated that short-term meditation programmes, such as MBSR and MBCT, induced functional and structural changes similar to long-term mediation in the prefrontal cortex, the cingulate cortex, the insula cortex and the hippocampus. A meta-analysis by Fox et al. (2014) found similar changes in meditation-naïve subjects affecting the anterior and posterior cingulate cortices, the insular cortex, the temporoparietal junction, the hippocampus, the caudate nucleus, and the cerebellum (21).

Functional and structural changes resulting from mindfulness meditation training thus affect several brain areas involved in and controlling movement including the prefrontal cortex, the basal ganglia, the cerebellum, and the hippocampus. An improved planning of movement in the prefrontal cortex, a better organization of complex movement sequences in the premotor cortex (66), an accelerated planning and control of voluntary movement in the basal ganglia including self-initiated movements through outputs to the premotor and supplementary motor areas might correlate to these changes (67), while the cerebellum might be enhanced in its function to act as a comparator to modulate muscle tone, participate in the programming of the motor cortex for movement execution, and contribute to the spatial timing of movement (67, 68). Another aspect of improving motor performance is linked to memory and motor learning in the hippocampus. This region plays a key role in encoding relevant associations between new stimuli and motor responses (69).

We believe that this neural plasticity observed in meditators is reasonable evidence to assume that arm and hand function in patients with stroke might be improved by meditation (Figure 1).

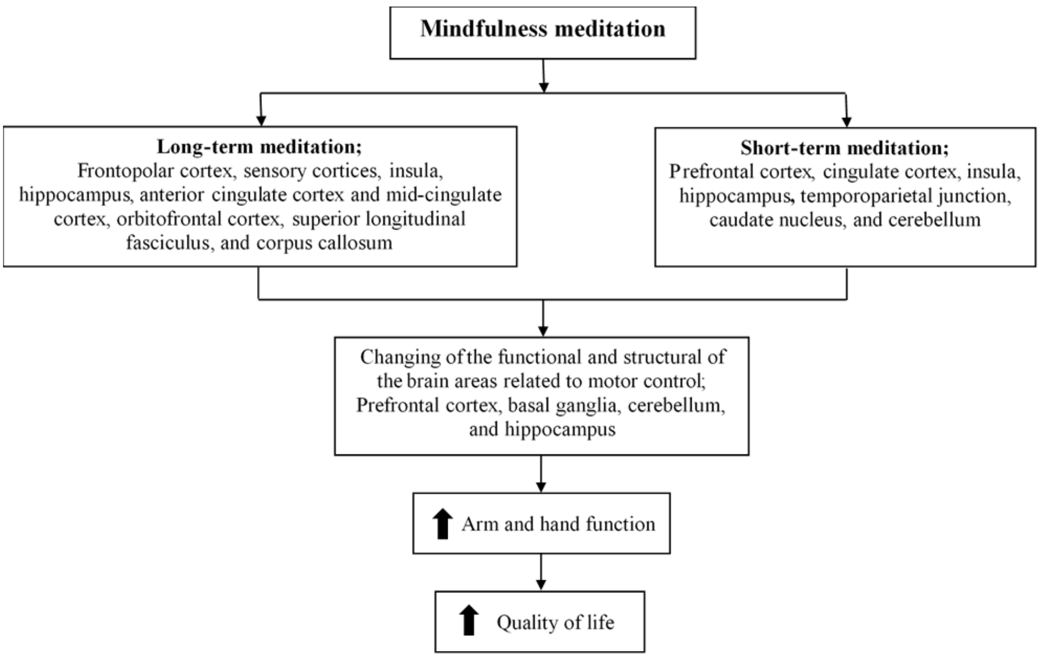

Figure 1. The hypothesised of mindfulness meditation on arm and hand function in patients with stroke.

2.5 Meditation in patients with stroke

The empirical evidence demonstrated that meditation could be applied with significant benefits in a variety of health conditions such as anxiety, depression, chronic pain, cancer, dermatological conditions, cardiovascular disease, and stroke (15, 37, 70). In the last ten years, numerous researchers investigated the effects of meditation in patients with stroke (3, 27).

Two systematic reviews were found that examined the effects of mindfulness meditation in patients with stroke including the effects of yoga and meditation (3) and the effects of MBI (27) in 2013. Lazaridou et al. (2013) collected articles about yoga and meditation in patients with stroke from 1990 to 2013. There were ten articles that met the specified criteria. The results showed positive effects on cognition, mood, stress and balance. Yoga and meditation probably affected a change in patients' mindsets and resulted in behaviour change, which ultimately improved their health. Therefore, yoga and mindfulness could become the main form of alternative medicine and treatment may be a valuable clinical option for patients with stroke. Moreover, Lawrence et al. (2013) collected studies about the effects of MBI programmes including MBSR and MBCT on patients with transient ischemic attack (TIA) or stroke from 1980 to 2012. There were four articles that met the inclusion criteria and in total 160 participants. Three studies used MBI in the group format, and one study used a one to one approach. There were three studies investigating the effects of MBSR and one study evaluating the effect of MBCT. The results demonstrated that the MBI has positive effects on anxiety, depression, mental fatigue, blood pressure, perceived health, and quality of life in patients with stroke. Furthermore, there was no evidence for any harmful side effects of the MBI programmes. However, this systematic review includes a small number of articles using poor methodologies.

Most studies of meditation in patients with stroke focused on psychological, physiological, and neuropsychological outcomes. These studies have found that mindfulness meditation can reduce anxiety, depression and mental fatigue, resulting in reduced levels of disability and improved quality of life in patients with stroke (3, 27). Therefore, it has been argued that meditation should be integrated into the management of stroke patients (17).

2.6 Mindfulness movement therapy programme

As shown by the above literature review, mindfulness meditation has been adapted and integrated into standardised mindfulness-based intervention programmes for improving physiological and psychological well-being such as MBSR and MBCT (51). However, none of these programmes have been developed to help patients following stroke with their associated motor deficits. Therefore, this thesis proposes a new concept of a MMTP for patients with motor impairments following stroke. The programme is based on MBSR and MBCT and consists of body scan, sitting meditation and, in particular, mindful-movement. Body scan was integrated to produce detailed awareness to each part of the body. Participants start with a training to keep their attention focused over a certain period of time that nurtures and develops greater stability of mind, calmness, and mindfulness. Sitting meditation then focuses participants on the sensation of the breath and thus cultivates an attitude of patience and gentleness. Mindful-movement is based on a passive or active range of motion and proprioceptive neuromuscular facilitation (PNF) patterns of the upper extremities. It cultivates greater mindfulness of the body in movement with a focus on the sensations arising from movement.

CHAPTER THREE

MEDITATION FOR MOTOR FUNCTION IN PATIENTS WITH STROKE: A SYSTEMATIC REVIEW

3.1 Chapter overview

This chapter presents a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. This chapter has been registered with the International Prospective Register of Systematic Reviews (PROSPERO) database and is being submitted for publication in the journal of "Mindfulness". I illustrate the search strategy for the included studies involving the effects of meditation on motor function and other outcomes in patients with stroke. After that, I demonstrate qualitative synthesis including assessing the risk of bias and quality of the 13 included studies. Finally, discussion and a summary of the evidence are presented. The results from this systematic review were adapted to develop a meditation programme for improving arm and hand function following a stroke.

3.2 Rationale

Numerous researchers have investigated the effects of meditation in patients with stroke in recent years (3, 27). It has been suggested that mindfulness meditation has potential benefits for treating anxiety, depression, chronic pain, impairment of working memory and attention (71). In 2013, there were two systematic reviews about mindfulness in patients with stroke (3, 27). Lazaridou et al. (2013) conducted a systematic review to analyse the effectiveness of yoga and mindfulness practices for stroke rehabilitation. Ten studies were included, which were conducted between 1990 and 2013 and included five randomised control trials (RCTs), four single case studies, and one qualitative study. The results showed that yoga and mindfulness could improve mood, cognition, balance, and reduce stress in patients with stroke. The review focused only on mindfulness along with yoga, which meant that the authors limited their search terms and did not include other meditation types where yoga was not present in the programmes such as MBCT. Lawrence et al. (2013) conducted a systematic review to evaluate the effect of MBIs on the outcome of TIA and stroke. Four eligible studies were included, conducted between 1980 and 2012 with 160 participants. They included articles that investigated only MBIs consisting of MBSR and MBCT. The primary outcome was perceived stress, and no studies have reported on this outcome. They also reported a positive effect on depression, anxiety and mental fatigue as well as on blood pressure and quality of life. However, the review contained a small number of studies with weak methodologies. Moreover, the results did not explore motor function.

In sum, our understanding of the potential benefits of meditation for stroke rehabilitation, particularly for recovering motor function, is still limited. For this reason, I conducted a systematic review to investigate the effectiveness of meditation on motor function in patients with stroke.

3.3 Objectives

This systematic review assessed the effects of meditation on motor function and explored the potential benefits of meditation in patients with stroke.

3.4 Methods

This systematic review followed the guidelines of the PRISMA Statement (72, 73) and the recommendations of the Cochrane Collaboration (74). The review protocol was registered with the PROSPERO database on 06 June 2018. The registration number was CRD42018098989 (Appendix I.).

3.4.1 Eligibility criteria

We included any available full-text quantitative study on patients with stroke aged 18 years or above but excluded systematic reviews and meta-analyses. To avoid exercise as a confounding variable, only interventions focused on formal meditation or interventions describing formal meditation as part of their curricula (MBSR and MBCT) were included, while interventions with substantial exercise components were excluded. Thus, studies focusing on yoga and tai chi were not considered eligible, even though yoga clearly involves meditation (75). For a broader perspective, all comparisons and all outcome measures were included with the primary outcome measure, which was motor function. The search included papers published up to June 2018 reported in the English language. The type of setting was not restricted.

3.4.2 Information sources

Literature search strategies used medical subject headings (MeSH) and text words related to meditation in patients with stroke. A literature search was undertaken using 1) health sciences databases; MEDLINE, Cochrane Library, CINAHL, PsycINFO, EMBASE; 2) databases outside health sciences especially multidisciplinary; Scopus, Web of Science, ProQuest, and ScienceDirect; 3) unpublished studies databases; ClinicalTrials.gov, WHO ICTRP, Conference websites, ProQuest Dissertation and Theses Global, BASE, British Library and Google Scholar. Databases were searched for matching articles in English language up to June 2018. Pilot directed searches combining the terms "stroke" and "meditation" and "motor outcome" missed to identify important studies. Therefore, databases were searched more broadly using the following terms: "stroke" or "post-stroke" or "cerebrovascular disease" or "CVA" or "hemiplegia" or "hemiparesis", in combination with "meditation" or "mindfulness" or "mindfulness meditation" or "Vipassana meditation" or "Zen meditation" or "mindfulness-based intervention" or "MBI" or "mindfulness-based stress reduction" or "MBSR" or "mindfulness-based cognitive therapy" or "MBCT". Additionally, reference lists of selected articles and other reviews were screened for additional eligible studies.

3.4.3 Search strategy

All databases mentioned above were searched. A librarian with specific knowledge in performing systematic review searches helped to create different search strategies. The finalised MEDLINE strategy was adapted to the syntax and subject headings for each database. A MEDLINE full search strategy example is shown in Appendix II.

3.4.4 Study records

3.4.4.1 Data management

Results of the database searches were stored and managed using Distiller Systematic Review (DSR) Software and Endnote X7.

3.4.4.2 Selection process

WY screened titles and abstracts. Study duplicates were removed, and any citation considered potentially relevant was retrieved in its full-text form to determine whether it met the selection criteria. Where necessary, first authors were contacted for additional information to resolve questions about eligibility. All selected articles were rechecked by JJ and disagreement on inclusion was resolved through discussion with HG. All decisions were made by consensus, and the reasons for excluding trials were recorded.

3.4.4.3 Data collection process

A data extraction form was developed, and the following data were extracted: authors, year of publication, trial objective, study design, sample size, population, intervention length, primary outcome, others outcomes, main findings. Retrieved data were checked by JJ for accuracy. If extracted data were discrepant, WY returned to the original article and clarified the correct information or contacted the study authors to resolve any uncertainties. Disagreements were resolved by discussion with HG.

3.4.5 Outcomes and prioritisation

The primary outcome was motor function provided it was measured with a standardised test such as Fugl-Meyer Assessment Upper Extremity (FMA-UE) and Lower Extremity scales, Wolf Motor Function Test, Action Research Arm Test (ARAT), Ten-Metre and Six-Minute Walk Tests (10MWT), or the Stroke Impact Scale (SIS). Secondary outcomes were any other reported measures.

3.4.6 Risk of bias in individual studies

The revised Cochrane risk of bias tool was used to evaluate the risk of bias (76), and the individual studies were rated according to the five domains of selection bias, performance bias, detection bias, attrition bias and reporting bias. Present bias was coded "1", while absence or unclear bias was coded "0". Not applicable was coded "N/A". If the study design was not a randomised controlled trial, the selection bias domain was considered as not applicable. The total available score was 10 with higher scores indicating a lower risk of bias. Judgments were made by WY, re-checked by JJ to confirm accuracy and discussed in case of disagreement if no consensus could be reached by consulting HG for arbitration.

3.4.7 Data synthesis

A descriptive qualitative synthesis of the findings from the included studies was put together and contained the type of intervention, target population characteristics, type of outcome and intervention details.

3.5 Results

3.5.1 Trial flow

The study selection process from identification to inclusion of studies is shown in Figure 2. Reasons for study exclusion are indicated. The flow diagram was produced using PRISMA (77). The literature search identified a total of 3034 articles. 3032 were identified through the databases, and two were identified via references. Duplicates were removed, and of the remaining 1216 articles, 1191 were excluded based on the title or abstract. Twenty- five full- text articles were retrieved and assessed for eligibility. Three articles were excluded because full- text was not available, two because of Chinese language, two were qualitative studies, one was a thesis that had used the same sample as the corresponding article, two did not include a mindfulness meditation component, and in two articles mindfulness meditation was combined with exercise. Finally, 13 articles met the inclusion criteria and were selected for qualitative synthesis.

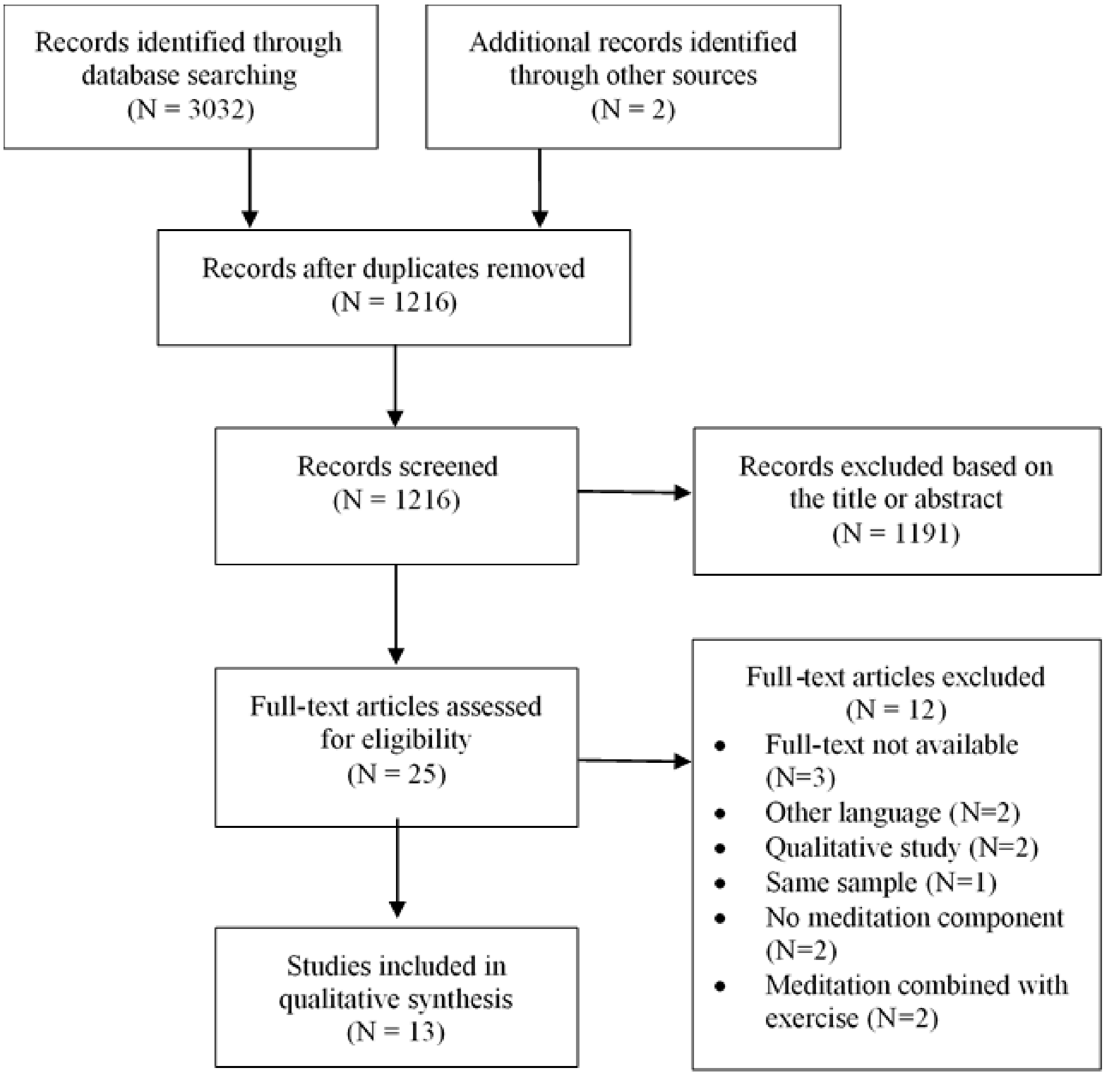

Figure 2. Flowchart of the literature search (Search performed 17.06.2018).

3.5.2 Study characteristics

Study characteristics and the results of each study are summarised in Table 1. Of the included studies, one study was a RCT (35), three studies were non-RCTs (78-80), six studies were uncontrolled trials (36, 37, 56, 71, 81, 82), and three studies were case reports (83-85). Of the four included controlled trials, one trial was a wait-list control design (35), two an active control design with either walking (78) or mind wandering (79), and one trial compared with treatment as usual (80). Only one study used a blind assessor design (80). Of the thirteen studies, four studies were conducted in the USA (79, 81, 83, 84), three in Sweden (35, 78, 82), and one each in Canada (37), Switzerland (36), UK (71), New Zealand (85), Korea (56), and China (80). Studies were conducted between 2007 and 2018. Of the four studies that had mixed of participants conditions, three studies included stroke patients and patients after traumatic brain injury (TBI) (35, 78, 82) while one study included seven patients with severe speech and physical impairment but only one patient with stroke (81). Only the data from patients with stroke were retrieved from these studies. The study sample sizes varied from 1 to 50, with a total of 183 patients with stroke. A total of 31 cases dropped out. Of the remaining 152 patients, 109 patients were instructed in meditation, and 43 served as a control group. The mean age of participants was 54.98 years ranging from 20 to 79 years. 72.03 per cent were men.

Table 1. Study characteristics and results of individual studies.

Study (author, year, country)	Study design	Participants (Total/ analysed sample size, experimental/control group)	Intervention (s)	Length of intervention	Control group	Follow-up period	Outcome measure	Main findings
Moustgaard et al. 2007, Canada	Uncontrolled trial	32/23, 23/- 17 males, 6 females 63.6 years	MBCT	9 weeks	-	3 months	**Psychological outcomes;** (1) Anxiety - Beck Anxiety Inventory (BAI). (2) Depression - Beck Depression Inventory, Revised (BDI-II). (3) Anxiety and depression - Hospital Anxiety and Depression Scale (HADS). **Psychosocial outcomes;** (1) Health status - 36-Item Short-Form General Health Survey (SF-36). (2) Quality of life - Stroke Specific Quality of Life Scale (SS-QOL).	BAI total, BDI-II, HADS, SF-36, and SSQoL total were statistically and clinically significant that reflected improvement after completion of the programme and maintenance at the 3-month follow-up.
Joo et al. 2010, Korea	Uncontrolled trial	28/11, 11/- 5 males, 6 females 52.64 years (38-65)	MBSR	8 weeks	-	-	**Psychological outcomes;** (1) Depression - Beck Depression Inventory, Korean version (BDI). (2) Anxiety - State-Trait Anxiety Inventory (STAI) **Physiological outcome;** (1) Autonomic nervous system (ANS) - Heart Rate Variability (HRV)	BDI was decreased statistically significant (p=0.013). In the HRV, there were increased statistically significant in standard deviation normal to normal (SDNN) (p=0.013), square root of the mean sum of squared differences between adjacent normal to normal intervals (RMSSD) (p=0.021), total power (TP) (p=0.026), lower frequency (LF) (p=0.008), and decreased statistically significant in mean heart rate (MHR) (p=0.007) and Physical Stress Index (PSI) (p=0.037).
Orenstein et al. 2012, USA	Case report (ABA design)	4/3, 3/- 2 males, 1 female 53 years (49-59)	MM	8 - 10 days	-	5 days	**Neuropsychological outcomes;** (1) Divided attention - Non-linguistic dual-task procedure, sense of effort (SOE), reaction time (RT), accuracy. (2) Language; Correct information units (CIU), Boston Diagnostic Aphasia Examination (BDAE).	There were no changes in the performance on the sense of effort or language detected. Reaction time may indicate that mindfulness meditation improved the efficiency of task completion.
Johansson et al. 2012, Sweden	Randomised controlled trials	18/16, 7/9 55.4 years This study included both stroke (n=18) and TBI (n=11). 26 participants completed the programme: 16 stroke and 10 TBI. The 16 stroke participants were divided into an experimental group (n=7) and a	MBSR	8 weeks	Waitlist control	-	**Psychological outcomes;** (1) Mental fatigue - Mental fatigue scale (MFS). (2) Depression and Anxiety - Comprehensive Psychopathological Rating Scale (CPRS). **Neuropsychological outcomes;**	The result combined the data of TBI and stroke, MFS was statistically significant between groups (p=0.008) and within MBSR group 1 (p=0.004) and MBSR group 2 (p=0.002). Depression was statistically significant within MBSR group 1 and 2 (p=0.006, p=0.002) and

Study (author, year, country)	Study design	Participants (Total/ analysed sample size, experimental/control group)	Intervention (s)	Length of intervention	Control group	Follow-up period	Outcome measure	Main findings
		waitlist control group (n=9). 10 TBI participants were divided into an experimental group (n=5) and a waitlist control group (n=5).					(1) Information processing speed - Digit Symbol-Coding, Digit Span from the WAIS-III scale. (2) Attention - Trail Making Test (TMT). (3) Working memory - F-A-S verbal fluency test.	anxiety within group 1 and 2 (p=0.004, p=0.02). TMT A was statistically significant between groups (p=0.032). TMT B and C were statistically significant between group 1 and control (p=0.013, p=0.039). MBSR significantly improved both, TMT C and Digit Symbol-Coding for both groups (TMT C; group 1: p=0.001, group 2: p=0.007, digit coding; group 1: p =0.026, group 2: p= 0.028). There was a significant increase in verbal fluency in MBSR group 1 (p=0.050) and group 2 (p=0.044) and a significant correlation of improvement in mental fatigue and information processing speed (p=0.023).
Hofer et al. 2014, Switzerland	Uncontrolled trial	8/8, 8/- 5 males, 3 females 48 years (20-61)	Mindfulness-enhanced, integrative neuro-psychotherapy programme	1 year (14-25 sessions)	-	-	**Psychological outcome;** (1) Mental fatigue - Self-assessment questionnaire for mental fatigue and related symptoms after neurological disorders and injuries (SQfMF)	SQfMF was a significant difference from pre- to post-treatment (p<0.017).
Merriman et al. 2015, UK	Uncontrolled trial	4/4, 4/- 3 males, 1 female 47 – 62 years	MBCT	9 weeks	-	-	**Psychosocial outcomes;** (1) Quality of life - WHO Quality of Life-BREF (WHOQoL-BREF). **Psychological outcomes;** (1) Mindfulness - Five Facet Mindfulness Questionnaire (FFMQ). (2) Anxiety and Depression - Hospital Anxiety and Depression Scale (HADS). **Neuropsychological outcome;** (1) Attention - Rating Scale for Attentional Problems (RSAP)	There were no statistically significant in all outcomes between pre and post-intervention. FFMQ improved 3/4 from 127 to 136, RSAP decreased 4/4 from 45 to 34, HADS Anxiety decreased 3/4 from 9 to 6, the HADS Depression decreased 2/4 from 7 to 6, WHOQoL-BREF not change

Study (author, year, country)	Study design	Participants (Total/ analysed sample size, experimental/control group)	Intervention (s)	Length of intervention	Control group	Follow-up period	Outcome measure	Main findings
Johansson et al. 2015a, Sweden	Non-randomized controlled trial	20/18, 5/7/6 48.5 years This study included an acquired brain injury comprising stroke (n=20) and TBI (n=18). 34 participants completed the programmes including 18 stroke and 16 TBI. 18 stroke participants were divided into 3 groups; MBSR face-to-face group (n=5), MBSR Internet group 1 (n=7), and walking control group (n=6). 16 TBI participants were divided into 3 groups; MBSR face-to-face group (n=7), MBSR Internet group 1 (n=6), and walking control group (n=3).	MBSR (live on internet)	8 weeks	MBSR (face-to-face), walking	-	**Psychological outcomes;** (1) Mental fatigue - Mental fatigue scale (MFS). (2) Depression and anxiety - Comprehensive Psychopathological Rating Scale (CPRS). (3) Self-compassion - Self-Compassion Scale (SCS) short form. **Neuropsychological outcomes;** (1) Information processing speed - Digit Symbol-Coding from the WAIS-III scale. (2) Attention - Attentional blink task.	Data of TBI and stroke were combined. Compared with the face-to-face and control groups MFS decreased significantly in the internet group, and there were significant pre-posttest improvements in the MBSR Internet group 1 with reduced MFS (p<0.001), depression (p=0.015), anxiety ratings (p=0.011) and improved processing speed on coding (p=0.031). There also was improved temporal attention on the attentional blink task, resulting in more correct T2 responses at the intermediate and the long time intervals, and more correct T1 responses at intermediate intervals (p=0.010). The face-to-face MBSR group improved similarly on the attentional blink task (0.038) and also made more correct T2 responses at the intermediate level. Participants in the control group (n=7) were allowed to attend the MBSR program later (MBSR Internet 2). They also showed significantly reduced MFS ratings after completion of the course (p<0.001) and had an improved attentional blink performance with significantly more correct T2 responses at the longest interval after the course (p=0.015).
Johansson et al. 2015b, Sweden	Uncontrolled trial	8/8, 8/- 3 males, 5 females 58.1 years This study included both stroke (n=8) and TBI (n=6).	Brahama Viharas	8 months	-	-	**Psychological outcome;** (1) Mental fatigue - Mental Fatigue Scale (MFS). **Neuropsychological outcomes;** (1) Information processing - Digit Symbol-Coding from the WAIS-III. (2) Visual scanning, divided attention, and motor speed - Trail Making Test (TMT).	The result combined the data of TBI and stroke were significant differences pre to post the advanced programme for MFS (p=0.001), Digit Symbol Coding (p=0.013), TMT B (p=0.018), and TMT C (p<0.001).
Goodrich et al. 2015, USA	Uncontrolled trial	1/1, 1/- 1 male 43 years	MM	6 weeks	-	-	**Psychosocial outcomes;** (1) Perceived Stress - Perceived Stress Scale (PSS).	In this study, no statistically significant pre-post intervention difference could be identified. The

Study (author, year, country)	Study design	Participants (Total/ analysed sample size, experimental/control group)	Intervention (s)	Length of intervention	Control group	Follow-up period	Outcome measure	Main findings
		This study included 7 individuals with severe speech and physical impairment including cerebral palsy (n=2), amyotrophic lateral sclerosis (n=2), spinocerebellar ataxia (n=1), muscular dystrophy (n=1), and brainstem stroke (n=1).					(2) Sleep - Pittsburgh Sleep Quality Index (PSQI). (3) Expectancy - Credibility/Expectancy Questionnaire. **Psychological outcome;** (1) Affect - International Positive and Negative Affect Schedule Short Form (I-PANAS-SF). **Neuropsychological outcomes;** (1) Attention - Attention Process Training II Attention Questionnaire (APT-II). (2) Working memory task - n-back task.	individual with stroke had following results: PSS (from score 6 to 0), PANAS positive (from score 24 to 25), negative (from score 8 to 5), PSQI (from score 1 to 4), APT-II (from score 19 to 1), n-back (from score 75 to 70).
Laures-Gore and Marshall 2016, USA	Case report	1/1, 1/- 1 female 60 years	MM	5 days	-	1 week	**Physiological outcomes**; (1) Autonomic nervous system (ANS) - Heart rate, heart rate variability (HRV), salivary cortisol **Neuropsychological outcomes;** (1) Language - the Five-item Revised Token Test (RTT), Aphasia Diagnostic Profiles (ADP), the Cognitive Linguistic Quick Test (CLQT). (2) Attention outcomes - Centre for Research on Safe Driving-Attention Network Test (CRSD-ANT), the Connor's Continuous Performance Task-II (CPT-II).	HRV increased, and BPM decreased at the third time point across the 3 days. Word productivity increased (B2=0.44, P3=0.94). RTT slight increased (B2=13.74, P3=14.18), CLQT increased (B2=15, P3=17, M4=16). CRSD-ANT; alert score increased (B2=-16, P3=114), orient score increased on the 4th assessment (B2=30, P3=17, M4=67), conflict score decreased (B2=160, P3=116). CPT; inattentiveness decreased, or attentiveness increased, impulsivity decreased in commissions and perseverations, vigilance stable.
Dickinson et al. 2017, New Zealand	Case report (ABA design)	1/1, 1/- 1 female 59 years	MM	4 weeks	-	3 weeks	**Psychological outcome;** (1) Anxiety -Beck Anxiety Inventory (BAI). **Neuropsychological outcomes;** (1) Language - Comprehensive Aphasia Test (CAT), Object and Action Naming Battery (OANB).	BAI decreased significant (p<0.0001). There were statistically significant in noun naming task (p=0.012), verb naming task (p=0.016), and repetition (p=0.021).
Marshall et al. 2018, USA	Non-randomized controlled trial	10/8, 5/3 5 males, 3 females 56.38 years (38–73) 6 Anomic, 1 Broca’s, 1 Conduction aphasia	MM with AMMP	5 days	Mind wandering	1 week	**Neuropsychological outcomes;** (1) Attention - Connor's Continous Performance Task-II (CPT-II), Centre for Research on Safe Driving-Attention Network Test (CRSD-ANT). (2) Language - discourse task, Aphasia Diagnostic Profiles (ADP), Cognitive Linguistic Quick Test (CLQT), the five-item Revised Token Test (RTT).	CPT-II and CRSD-ANT were not statistically significant within the group and between the groups. There were no significant differences in language outcome but improved fluency immediately after MM training. There were not change over the session in MM group in physiological outcomes.

Study (author, year, country)	Study design	Participants (Total/ analysed sample size, experimental/control group)	Intervention (s)	Length of intervention	Control group	Follow-up period	Outcome measure	Main findings
							Physiological outcomes; (1) Autonomic nervous system - Heart rate, HRV, salivary cortisol	
Wang et al. 2018, China	Non-randomized controlled trial	50/50, 25/25 44 males, 6 females 62.1 years (24-79)	MBI combined with usual care	2 weeks	Usual care	-	**Physiological outcomes;** (1) Comfort - Chinese Version of Shortened General Comfort Questionnaire (SGCQ). (2) Ambulation ability - Berg Balance Scale (BBS), 10MWT, Functional Ambulation Classification Scale (FAC). **Psychological outcome;** (1) Mindfulness; Chinese Version of Mindful Attention Awareness Scale (MAAS).	MAAS had statistically significant between groups (p<0.001), SGCO; in physical (p=0.004), psychospiritual (p=0.026), sociocultural (p=0.006), overall score (p=0.005); no significant in BBS, 10MWT, FAC between groups. MAAS, SGCQ, and each of its dimensions, BBS, 10MWT, and FAC significantly improved within the group for intervention and control groups (p<0.001).

Note: MBCT; Mindfulness-based cognitive therapy, MBSR; Mindfulness-based stress reduction, MM; Mindfulness meditation, MBI; Mindfulness-based intervention, AMMP; Aphasia mindfulness meditation programme, TBI; Traumatic brain injury

3.5.3 Interventions

Characteristics of the intervention programmes of each study are summarised in Table 2. Of the included studies, three studies used MBCT or components of MBCT (36, 37, 71), three studies used MBSR (35, 56, 78), four studies used mindfulness meditation (MM) (81, 83-85), one study used MM combined with aphasia mindfulness meditation programme (AMMP) (79), one study used Brahama Viharas (82), and one study used MBI (80). The length of training varied from 5 days to 1 year. Three trials involved eight weeks of intervention (35, 56, 78), two trials involved nine weeks of intervention (37, 71), two trials evaluated five days of mindfulness meditation (79, 84). Interventions in other trials were 8 to 10 days (83), two weeks (80), four weeks (85), six weeks (81), eight months (82), and one year (36). In all studies, the mode of delivery was face to face. One study used both, face to face and internet live mode (78) for delivery. Eight studies used group-based, and five studies used individual-based formats of intervention. The frequency of intervention was one day per week in the majority of studies. One study used interventions at one day per month (82), and two studies used daily practice of brief mindfulness meditation (79, 84). The length of intervention in a session varied from 30 to 150 minutes per week, with a median of 105 minutes. In total, interventions varied from 150 to 1620 minutes of practice, with a median of 945 minutes. Only three studies included the provision of a one-day retreat in addition to the programme (35, 78, 82). There were eleven studies that also included home practice. Of those, eight studies used daily home practice, two studies used six days per week, and one used 3 to 5 days per week. The session length of home practice varied from 20 to 60 minutes per day, with a median of 32.5 minutes (reported for 8 out of the 11 trials).

Table 2. Characteristics of the meditation used in the included studies.

Study	Meditation
Moustgaard et al. (2007)	9 weeks of modified MBCT, 1 ¾ hour per week but the essential content and approach (in group format) of MBCT was not changed. This programme had a specific theme each week. It included diverse length and forms of meditation techniques, modified yoga, cognitive therapy for focusing on prevention and treatment of depression, education about psychological and physical specific to stroke, group work, and homework.
Joo et al. (2010)	8 weeks of MBSR programme, once a week, 2.5 hours each. Body scan, sitting meditation, and Hatha yoga were used to train mindfulness in group format. In addition, 'loving-kindness meditation' was practised, and patients had time to share their experiences through group discussions. A compact disk (CD) was provided to enable the subjects to perform body scan, sitting meditation, yoga, and mindfulness as part of routine life.
Orenstein et al. (2012)	Mindfulness meditation was practised in a quiet, dimly lit room. Participants were instructed to notice distractions, pain, boredom and other feelings that arose while practising breathing techniques and to return the focus to their breath, other bodily sensations and/or to aspects of the environment. Training length was gradually increased from 5 to 30 minutes over a minimum of 4 sessions and meditation was also practised at home. Verbal and written take-home instructions were provided.
Johansson et al. (2012)	MBSR consisted of eight 2.5-hour group sessions once a week, a silent day between session six and seven and 45 minutes home practice on 6 days a week. A CD with guided instructions was provided for home practice. The interventions were based on Kabat Zinn's MBSR programme and included gentle Hatha yoga, body scan and sitting meditation.
Hofer et al. (2014)	A mindfulness-enhanced, integrative neuro-psychotherapy programme was used in this study on a one-to-one format, 20 sessions over the course of 1 year, 50 minutes per session. The intention of this study was to increase patients' awareness of fatigue and to help to detect and manage fatigue triggers in order to increase performance in daily functioning. Body scan as part of MBCT was used to train mindfulness to learn to identify strenuous activities and to determine the right time to take a break.

Study	Meditation
Merriman et al. (2015)	9 weeks of MBCT group format 2 hours each week. It included practising mindfulness formally and informally, encouraging mindful attitudes and reflecting on the practice. Participants' homework involved recording pleasant/unpleasant events and daily mindfulness practice. Session length was 3 minutes to 35 minutes. Mindfulness practices included the following: (1) breath: attending to breathing, (2) body scan: focuses on sensations in each body part, (3) movement/walking: focuses on bodily sensations during gently movement, (4) breath and body: focuses on breath, body and noticing pleasant or unpleasant sensations, (5) sounds and thoughts: attending to sounds and thoughts, (6) the breathing space: short exercise attending to thoughts, feelings and body, (7) the lake and the mountain: using the mountain lake metaphor to focus on breath, body and thoughts, (8) everyday mindfulness: incorporating mindfulness into activity (e.g. walking, eating).
Johansson et al. (2015a)	Live online MBSR: an internet-based full MBSR curriculum including formal practices, home practice support, and informal practices. Eight 2.5-hour sessions once a week, one 7-hour session between the 6th and 7th sessions, and home practice. The Adobe Connect platform was used for online meetings covering full video and audio support for all group participants, enabling participants to share experiences and to learn from one another, to increase their insights into mindfulness similar to face-to-face groups.
Johansson et al. (2015b)	Brahama Viharas: eight 2.5-hour group sessions once a month, one all-day retreat. The four boundless mental states of the Brahama Viharas (compassion, metta, appreciative joy, and equanimity) were used to train mindfulness. The mental state of appreciative joy was explored and practised as "taking in the good".
Goodrich et al. (2015)	Six 1.5-hour sessions of mindfulness meditation programme in a one-on-one format at a research lab once a week followed by daily home practice. Home practice training length was gradually increased from 25 to 35 to 45 minutes over 3 weeks. The meditation programme included the following topics: mindfulness of sounds, mindfulness of breath, loving-kindness meditation, and participant choice.
Laures-Gore and Marshall (2016d)	5-days mindfulness meditation individual training and daily practice with the intention to enhance attention and present-moment awareness. Participants were instructed to pay attention to the breath and other bodily sensations, to notice distractions and to return the focus to their breath, bodily sensations and/or to the aspects of the environment. Training

Study	Meditation
	length was gradually increased from 10 to 30 minutes over 4 sessions. In addition to trainer sessions, participants were instructed to practice mindfulness meditation at home on a daily basis. Training length for home practice was identical to the length of training sessions that day. With respect to the participants' aphasia, information was presented at a slow rate and questions were asked to confirm comprehension.
Dickinson et al. (2017)	4 weeks of mindfulness meditation programme, 1½–2-h weekly in a one-on-one setting based on MBSR in the style of Kabat-Zinn. The clinical psychologist adapted the usual 8-week group course to make a 4-week one-on-one programme, individualised for the participant and conducted at the practitioner's clinic. The speech and language therapist provided supportive communication training to the psychologist prior to commencement of the programme, as well as being present during the first session to assist with communication needs. The contents for each week were as follows: (1) breath awareness with focus on the belly and mindful eating; (2) sitting meditation and body scan; (3) sitting meditation and four step for reducing arousal including stop, take a breath, observe, proceed; (4) walking meditation, and acceptance and allowance meditation. The participant implemented an almost daily home meditation practice into her routine. She mostly practised body scanning as she felt this was most useful.
Marshall et al. (2018)	5-days mindfulness meditation in a group format combined with AMMP with the intention to enhance attention and present-moment awareness. Participants were instructed to pay attention to the breath and other bodily sensations, to notice distractions and to return the focus to their breath, bodily sensations and/or to aspects of the environment. Training length was gradually increased from 10 to 30 minutes. Participants were also instructed to practice mindfulness meditation at home based on the instructions provided in the daily sessions. Training length for home practice was identical to the length of training sessions that day. With respect to language deficits associated with aphasia, instructions were simplified and graphics support was provided. A CD with guided instructions was provided.
Wang et al. (2018)	Participants in the intervention group received both routine care and the mindfulness-based intervention. The MBI was a 2-week intensive mindfulness practice programme, which included weekly 1.5-hour group practice sessions and individual daily practice. It was designed based on Eifert and Forsyth's (2005) centring exercise, a fundamental mindfulness practice that can assist in the preliminary

Study	Meditation
	development of mindfulness skill, relieve physical and psychological tension and comfort, and improve attention and commitment. Nonprofessional caregivers of participants were invited to participate during group practice sessions to promote their understanding of the programme and to offer participant support.

3.5.4 Outcome measures

3.5.4.1 Motor function

The majority of included studies were focused on aphasia (N=5), mental fatigue (N=4), and anxiety and depression (N=2). There were only three studies measuring motor function; 1) Wang et al. (2018) measured ambulation ability with the Berg Balance Scale (BBS), 10MWT, and Functional Ambulation Classification Scale (FAC), 2) Moustgaard et al. (2007) measured mobility and upper extremity domains with Stroke Specific Quality of Life Scale (SS-QOL) and measured physical health components with the 36-Item Short-Form General Health Survey (SF-36), and 3) Merriman et al. (2015) measured the physical quality of life domain with WHO Quality of Life-BREF (WHOQoL-BREF).

3.5.4.2 Further outcomes

Several measures were applied to investigate the effects of meditation practice (Figure 3). The outcomes are grouped into the domains as follows: physiological, psychological, psychosocial and neuropsychological.

3.5.4.2.1 Physiological outcomes

There were four studies measuring physiological outcomes: the autonomic nervous system (ANS) functioning, comfort, and ambulation ability. Three studies measured ANS functioning with heart rate (79, 84), heart rate variability (HRV) (56, 79, 84), and salivary cortisol (79, 84). One study used the Chinese Version of the

Shortened General Comfort Questionnaire (SGCQ) and measured ambulation ability with BBS, 10MWT, and FAC (80).

Figure 3. Measures applied in studies: numerical proportions

3.5.4.2.2 Psychological outcomes

Psychological outcomes were the most commonly assessed in 10 studies, with many studies including more than one psychological measure. Seven measures in total were classified in the domain of psychological outcomes including anxiety, depression, anxiety and depression, mental fatigue, affect, mindfulness, and self- compassion. Anxiety was assessed by three studies with the Beck Anxiety Inventory (BAI) (37, 85) or the State-Trait Anxiety Inventory (STAI) (56). Depression was assessed by two studies with the Beck Depression Inventory, Revised (BDI-II) (37) and the Korean version of the Beck Depression Inventory (BDI) (56). There were four studies measuring both anxiety and depression at the same time with the Hospital Anxiety and Depression Scale (HADS) (37, 71) or the Comprehensive Psychopathological Rating Scale (CPRS) (35, 78). Mental fatigue was assessed by four studies with two different questionnaires including of the mental fatigue scale (MFS) (35, 78, 82) and the self-assessment questionnaire for mental fatigue and related symptoms after neurological disorders and injuries (SQfMF) (36). One study used the International Positive, and Negative Affect Schedule Short Form (I-PANAS-SF) for measuring affect (81) and one study used the short form of the Self-Compassion Scale (SCS) for measuring self-compassion (78). Two studies measured mindfulness with the Five Facet Mindfulness Questionnaire (FFMQ) (71) and the Chinese Version of the Mindful Attention Awareness Scale (MAAS) (80).

3.5.4.2.3 Psychosocial outcomes

Five measures were assessed in three studies comprising of health status, quality of life, perceived stress, sleep disturbance, and expectancy. One study measured health status with the SF-36 (37). Quality of life was assessed by two studies with SS-QOL (37) and WHOQoL-BREF (71)**.** Goodrich et al. (2015) evaluated the other three outcomes with the Perceived Stress Scale (PSS), the Pittsburgh Sleep Quality Index (PSQI), and the Credibility/Expectancy Questionnaire.

3.5.4.2.4 Neuropsychological outcomes

Nine studies assessed five neuropsychological outcomes consisting of attention, divided attention, language, information processing speed, and working memory. Attention was examined by seven studies with six different outcomes including the

Trail Making Test (TMT) (35, 82), the Rating Scale for Attentional Problems (RSAP) (71), the Attentional blink task (78), the Attention Process Training II Questionnaire (APT-II) (81), the Centre for Research on Safe Driving-Attention Network Test (CRSD-ANT) (79, 84), and the Connor's Continuous Performance Task-II (CPT-II) (79, 84). One study assessed divided attention with the non-linguistic dual-task procedure (83). Language was assessed by four studies in eight different outcomes consisting of the Correct information units (83), the discourse task (79), the Boston Diagnostic Aphasia Examination (BDAE) (83), the Five-item of the Revised Token Test (RTT) (79, 84), the Aphasia Diagnostic Profiles (ADP) (79, 84), the Cognitive Linguistic Quick Test (CLQT) (79, 84), the Comprehensive Aphasia Test (CAT) (85), and the Object and Action Naming Battery (OANB) (85). Three studies measured information processing speed with the Digit Symbol-Coding from the WAIS-III scale (35, 78, 82). Working memory was evaluated by two studies with the F-A-S verbal fluency test (35) and the n-back task (81).

3.5.5 Timing of assessment

Baseline assessment and immediate post-treatment assessment was conducted in all included studies. Five studies also conducted post-treatment follow-up assessments. The timing of follow up assessment varied considerably and ranged from 5 days to 3 months.

3.5.6 Study quality (risk of bias)

Table 3 presents a summary of the risk of bias. Of the 13 included studies, there was only one RCT, and due to the nature of the intervention, all of the studies were at risk of bias in the domains of adequate random sequence generation, adequate allocation concealment, adequate participants blinding, and adequate treatment provider blinding. Only the RCT study had similar baseline characteristics (35), one study had assessor blinding (80), and one study reported an intervention-to treat analysis (78). In contrast, all studies reported no selective outcome reporting. Most of the studies described the dropout rate. There were four studies reporting similar timing of outcome assessments in RCT and non-RCT. The studies achieved the revised Cochrane risk of bias scores in the range of 1 to 4 points (mean=2.38, SD=1.04) out of a possible 10 points.

3.5.7 Quantitative synthesis

Statistical meta-analysis was not possible. Due to a limitation of comparable studies, there was only one RCT and three non-RCTs. Overall, the quality of the studies was low. The interventions varied considerably with respect to type, frequency and intensity, and outcome measures were different, too. In addition, we contacted the lead author of three studies for further data but have not obtained a response.

Table 3. Assessment of risk of bias (76)

Study (authors, years)	Study design	Selection bias			Performance bias		Detection bias		Attrition bias		Reporting bias	Total (max. 10)
		Adequate random sequence generation N/A if not RCT	Adequate allocation concealment N/A if not RCT	Similar baseline characteristics N/A if not RCT	Adequate participants blinding	Adequate treatment provider blinding	Adequate outcome assessor blinding	Similar timing of outcome assessment	Acceptable and described dropout rate	Inclusion of an intervention-to treat analysis	No selective outcome reporting	
Moustgaard et al. (2007)	Uncontrolled trial	N/A	N/A	N/A	No	No	No	No	Yes	No	Yes	2
Joo et al. (2010)	Uncontrolled trial	N/A	N/A	N/A	No	No	No	No	Yes	No	Yes	2
Orenstein et al. (2012)	Case report (ABA design)	N/A	N/A	N/A	No	No	No	No	Yes	No	Yes	2
Johansson et al. (2012)	Randomised controlled trials	Unclear	Unclear	Yes	Unclear	Unclear	Unclear	Yes	Yes	No	Yes	4
Hofer et al. (2014)	Uncontrolled trial	N/A	N/A	N/A	No	No	No	No	Yes	No	Yes	2
Merriman et al. (2015)	Uncontrolled trial	N/A	N/A	N/A	No	No	No	No	Yes	No	Yes	2
Johansson et al. (2015a)	Non-randomized controlled trial	N/A	N/A	N/A	Unclear	No	Unclear	Yes	Yes	Yes	Yes	4
Johansson et al. (2015b)	Uncontrolled trial	N/A	N/A	N/A	No	No	No	No	Yes	No	Yes	2
Goodrich et al. (2015)	Uncontrolled trial	N/A	N/A	N/A	No	No	No	No	Yes	No	Yes	2
Laures-Gore and Marshall (2016)	Case report	N/A	N/A	N/A	No	No	No	No	N/A	No	Yes	1
Dickinson et al. (2017)	Case report (ABA design)	N/A	N/A	N/A	No	No	No	No	N/A	No	Yes	1
Marshall et al. (2018)	Non-randomized controlled trial	N/A	N/A	N/A	Unclear	No	Unclear	Yes	Yes	No	Yes	3
Wang et al. (2018)	Non-randomized controlled trial	N/A	N/A	N/A	Unclear	No	Yes	Yes	Yes	No	Yes	4

Note: N/A not applicable, the answer ‘yes’ coded = 1, ‘unclear’ and ‘no’ = 0 score. The total score is 10. Higher scores indicate a lower risk of bias.

3.6 Discussion

This is the first systematic review exploring the effects of meditation on motor function in patients with stroke. Thirteen studies (one RCT) examining all types of meditation were included, and the effects on motor function and other outcomes were assessed.

Only three studies in this review investigated motor function in stroke patients including one non-RCT (80) and two non-controlled studies (37, 71). Due to data limitations and differences in interventions, outcomes and designs of these studies, it was not possible to undertake a meta-analysis synthesis. In terms of motor function, only one non-controlled study demonstrated significant improvements in mobility, in the upper extremity domains of SS-QOL and the physical health components of SF-36 after completion of 9 weeks of MBCT (37). BBS, 10MWT and FAC did not significantly change between groups after completing MBI for two weeks (80), and the physical domain of general quality of life (WHOQoL-BREF) had not changed after nine weeks of MBCT (71). In summary, these findings indicate that high-quality studies are necessary to monitor motor function and its potential improvement through meditation practice.

The second objective of this review was to explore other potential benefits of meditation in patients with stroke. Although it is not technically possible to show evidence based on meta-analysis, the majority of included studies demonstrated positive effects of meditation in various domains including physiological, psychological, psychosocial, and neuropsychological outcomes. The majority of studies were focused on anxiety, depression, mental fatigue, and aphasia. Within the six studies investigating the effect of meditation on anxiety and depression, there was heterogeneity of study design (two comparison studies, three non-controlled studies, and one case report), type of meditation (two MBCT, three MBSR, and one MM), and outcome measures for anxiety and depression (BAI, BDI-II, STAI, HADS, and CPRS). However, five in six studies reported that meditation could decrease symptoms of anxiety and depression, although the sample sizes were small. In terms of mental fatigue, four studies (two comparison studies and two non-controlled studies) investigated the effect of MBSR (two studies), MBCT (one study) and Brahama Viharas (one study) with MFS (three studies) or SQfMF (one study). Meditation practice statistically significantly reduced mental fatigue and related symptoms (MFS and SQfMF), either between intervention and control groups or within the intervention group demonstration before/after-effects. Moreover, researchers have begun to manage aphasia problems with mindfulness practice. Studies demonstrated that MM improved language outcomes after completing a mindfulness meditation programme, and Marshall et al. (2018) proposed an AMMP for patients with stroke and aphasia. Although the authors could not demonstrate a significant difference in language outcome, speech fluency improved immediately after a short 5-day training. A systematic review by Lawrence et al. (2013) also evaluated the effectiveness of mindfulness-based interventions in patients with TIA and stroke and included four studies with a total of 160 participants. The results reported were consistent with our systematic review, suggesting that MBIs could reduce symptoms of anxiety, depression, and mental fatigue.

3.7 Summary of evidence

There were inadequate data to confirm the effectiveness of meditation on motor function or other outcomes in patients with stroke. This review was limited by the availability of high-quality studies, the small sample size in each study, and variability in the methodological quality. The included studies differed widely in relation to study design, intervention, and outcome measures, therefore restricting the potential of comparisons between studies. Due to the above problems, a meta-analysis could not be performed, and a qualitative analysis was required instead. We found that overall the included studies had a high risk of bias and the methodological quality was low.

3.8 Limitations

Limitations in this systematic review are a lack of active comparison studies, small sample sizes and the fact that quantitative meta-analysis was not possible due to the wide variety of study design, intervention, and measure outcomes. Moreover, the review found that there was a high risk of bias with respect to selection, performance, assessor blinding and intervention to treat. Finally, the review included only quantitative studies and articles published in English.

3.9 Conclusions

From the limited data available, the present systematic review suggests that meditation may be of benefit in patients with stroke to improve motor function and other outcomes such as anxiety, depression, mental fatigue, and aphasia**.** However, there is a significant lack of conclusive evidence in this relatively new area of research. Therefore, further studies including high-quality RCTs are required to confirm the effectiveness of meditation on the rehabilitation of motor function in patients with stroke. Particular limitations of the currently available evidence need to be addressed, for example, the lack of active treatment control and small sample sizes.

3.10 Implications for clinical practice

This systematic review demonstrated that meditation may be of benefit to some physiological, psychological, psychosocial, and neuropsychological outcomes, especially anxiety, depression, mental fatigue, and aphasia, but we found no conclusive evidence of effectiveness in improving motor function in patients with stroke, which may be because most studies have not used motor function as an outcome measure. However, there was also no evidence of harm from meditation, which is inexpensive to deliver, requires little resources, and is flexible in terms of delivery location. Therefore, the use of meditation still offers the potential to enhance standard treatment.

CHAPTER FOUR

THE EFFECT OF A MINDFULNESS MOVEMENT THERAPY PROGRAMME ON THE MOTOR PERFORMANCE OF THE UPPER LIMBS IN OLDER ADULTS: A PRELIMINARY STUDY

4.1 Chapter overview

This chapter presents a new protocol of MMTP which is designed for improving motor function in patients with stroke. The feasibility of this MMTP was tested by investigating the effects on motor performance of the upper limbs in older adults. The results of the MMTP are presented on motor performance, oscillatory activity over sensorimotor cortex, attentional performance in the sensorimotor system, psychological outcomes, mindfulness, and quality of life in a sample taken from the United Kingdom older population. A shorter version of this chapter is being submitted as a manuscript to the journal of "Physiotherapy".

4.2 Rationale

Upper limb impairments are common after a stroke (14, 86). They are ordinarily seen in around 70 per cent of stroke survivors (86, 87), and include motor and somatosensory deficits (86, 88, 89). Upper limb weakness occurs in around 85 per cent (89) and somatosensory deficit in around 78 per cent of patients with stroke (88). These impairments are often persistent and linked to long-term disability (14, 90). There is only a small percentage of patients (5 to 20 per cent) who make a full recovery (91, 92). Another 33 per cent to 66 per cent of patients have no recovery of hand and arm function at six months post-stroke (91). Finally, 50 per cent of patients with initial upper limb impairment still have problems with hand and arm function four years post stroke (14). The recovery of function in the upper limbs is made relatively difficult because stroke patients tend to use their affected side less (87). Consequently, upper limb impairments reduce patients' ability to perform daily activities such as eating, dressing and washing (14, 90). One year following a stroke, upper limb disability can also affect patients' emotional well-being and mental health as measured in terms of increased anxiety and depression (12, 14, 90). Eventually, stroke patients report reduced social participation and quality of life (87, 93). Therefore, rehabilitation of the upper limbs is crucial for improving patients' quality of life and for reducing the complications that can occur from limiting movement of the affected side (89). In sum, restoration of hand and arm function should be considered a core element of neurorehabilitation post-stroke to maximise recovery (14, 92). In reality, however, patients and therapists often pay more attention to improving walking ability (87), neglecting upper limb function as a result (87, 93). Systematic reviews demonstrated that the average length of time spent in the treatment of upper limb function is only between 0.9 to 7.9 minutes, with only 32 repetitions per session (87, 93, 94). Therapists have developed a variety of techniques and treatments for the management upper limb dysfunction in patients with stroke (14). However, it is still unclear which upper limb intervention approaches are the most effective ones for improving arm and hand function in patients with stroke (14).

At present, mindfulness meditation is one of the interventions that is gaining more widespread attention (3, 27). It has been used more and more frequently in patients with stroke and has shown a positive affect on both, physical and psychological well-being (3, 27, 71). The systematic review of Lazaridou et al. in 2013 summarized articles about yoga and meditation in patients with stroke from 1990 to 2013. The authors found that yoga and meditation showed positive effects on cognition, mood, stress and balance. A further systematic review of Lawrence et al. in 2013 included studies from 1980 to 2012 on the effects of MBI programmes including MBSR and MBCT in patients with TIA or stroke and demonstrated positive effects on anxiety, depression, mental fatigue, blood pressure, perceived health, and quality of life. In consequence it has been argued that mindfulness meditation should be integrated into traditional rehabilitation programmes for the management of stroke (3, 17, 27). In addition to our systematic review presented in Chapter 3, there are only three studies (37, 71, 80) that have analysed the effect of meditation on motor function in patients with stroke, including MBI and MBCT, and currently there is no specific mindfulness programme established for improving motor function in patients with stroke.

While preliminary evidence suggested that both, short-term and long-term mindfulness meditation practice, can induce structural and functional changes in brain areas related to movement control like the prefrontal cortex, the hippocampus, the cerebellum, and the corticospinal tract (21, 23), neuroplasticity of these brain areas may have a direct effect on the recovery of arm and hand function following stroke. We therefore were interested in developing a specific mindfulness programme for the rehabilitation of arm and hand function in patients with stroke and proposed and tested a MMTP protocol intended for investigating the effects of mindfulness meditation on improving the upper limb motor function in older adults with stroke. The feasibility of this MMTP protocol was measured by examining its effects on motor function and their underlying sensorimotor cortical mechanisms.

Electroencephalography (EEG) was used for evaluating the sensorimotor attentional and cortical motor function. EEG is an easy to use, inexpensive and widely used tool with a high temporal resolution for measuring neural oscillatory activities (95). It is also commonly used to monitor neurophysiological changes associated with meditation (60, 96). It measures summed post-synaptic electrical activity of the cerebral cortex (96) in the theta (4–7 Hz), alpha (8–12 Hz), beta (13–30 Hz), and gamma (30–50 Hz) frequency bands (60, 97, 98). Mu rhythm refers to the alpha band and is recorded over the sensorimotor cortex (99). An event-related increase in the power of the EEG signal is called event-related synchronisation (ERS) while an event-related decrease is called event-related desynchronisation (ERD) (98). Earlier studies demonstrated that both, actual and imagined movement is linked to mu rhythm desynchronisation over the sensorimotor cortex (97-100), and specific changes have been used to monitor the recovery of motor functions in patients with stroke (100) with the magnitude of mu alpha desynchronisation linked to the effectivity of sensorimotor function (101-103).

Mu rhythm measured over the sensorimotor cortex during imagined hand and arm movements were used for comparing MMTP to an active control (AC) and to a no-intervention group. Effects on mindfulness, mood, perceived stress, and quality of life were also measured.

4.3 Objectives

4.3.1 Primary objective:

To investigate the feasibility and the effects of MMTP on motor performance of the upper limbs in older adults.

4.3.2 Secondary objectives:

To investigate the effects of MMTP on cortical sensorimotor activities (mu alpha oscillations and somatosensory P300), attentional performance, mindfulness, mood, perceived stress and quality of life in older adults

4.3.3 Specific objectives:

1) To compare the Jebsen Hand Function Test (JHFT) score between and within control, active control and experimental groups at baseline and week 8.
2) To analyse and compare mu alpha oscillatory activity with electroencephalography (EEG) and the P300 component of somatosensory event-related potentials (ERPs) between and within active control and experimental groups at baseline and week 8.
3) To compare the short-form Freiburg Mindfulness Inventory (FMI) between and within active control and experimental groups at baseline and week 8.
4) To compare the Profile of Mood States-Short Form (POMS-SF) between and within active control and experimental groups at baseline and week 8.
5) To compare the Perceived stress scale (PSS-10) between and within active control and experimental groups at baseline and week 8.
6) To compare the Older People's Quality of Life (control, autonomy, satisfaction, pleasure domains) (CASP-19) between and within active control and experimental groups at baseline and week 8.

4.4 Methods

4.4.1 Trial design

Stratified, block randomised, prospective cohort study conducted at the Centre for Brain Science, Department of Psychology, Colchester campus, University of Essex, the United Kingdom from August 2015 to March 2017. The study was approved by the University of Essex, Faculty of Science and Health Ethics Committee (Appendix III).

4.4.2 Participants

Eligible participants were between 50 to 70 years of age, of either gender. Exclusion criteria were severe psychiatric or neurological diseases, diabetes mellitus with numbness of limbs and significant cognitive impairment (standardised mini-mental state examination < 26). All participants provided informed consent before taking part in the study.

4.4.3 Sample size

This study was a preliminary study which examined the feasibility and the effectiveness of the MMTP, in order to obtain data for a further study and to calculate the sample size for the main study. Therefore, the sample size in this study was based on previous studies using approximately 7 to 11 participants in each group (35, 56).

4.4.4 Randomisation

Participants in the MMTP and AC groups were randomly allocated with a computer generating blocks of random numbers and stratified by age, gender, education level, depression condition, and experiences of meditation. Non-randomized preference was used in the passive control group.

4.4.5 Intervention

Eligible participants were randomly assigned to receive the MMTP, active control intervention, or no intervention.

4.4.5.1 MMTP group

Participants received body scan for 10 minutes, sitting meditation for 10 minutes, and mindful- movement for 10 minutes. After baseline assessment, participants were described MMTP and were trained in 9 positions of mindful-movement until they could do it correctly. After that, they were guided by listening to a compact disc (CD) at home for 30 minutes, 3 times a week on non-consecutive days, for 8 weeks and recorded their compliance using a Logbook (Appendix IV).

MMTP was designed for people who have motor deficits and is based on MBSR and MBCT. The MMTP is an 8-week programme which consists of the body scan, sitting meditation and, in particular, mindful-movement. The body scan is performed to bring total attention and awareness of any sensations in each part of the body while accepting all sensations or feelings that occur. Participants learned to stay in the present moment by keeping their attentional focus on each part of the body, nurturing mindfulness. The participants sat on a chair with a straight back, while resting their dominant hand on their thigh, and placing their non-dominant hand on the table, with the palm facing towards the ceiling. Participants paid full attention to each part of the non-dominant upper limb, as the scan went from finger to shoulder. Sitting meditation cultivates an attitude of patience and gentleness. The participants sat on a chair with a straight back, while resting their hands on their thighs. In the beginning, participants focused on the sensation of the breath moving past the nostrils, following the sensation of the breath as it came in and out. They used the breath as an anchor to bring them back to the present moment whenever they noticed that their mind was wandering. After that, they moved their focus toward hearing, expanding the awareness to include thinking and thoughts by accepting and letting them go. At the end of the practice period, they observed all sensory experiences with non-doing and non-judgment. The mindful-movement practice is about achieving and maintaining moment to moment awareness of the performed movements (104). The aim is not physical strengthening but gives another opportunity to cultivate greater mindfulness of the body in movement. Mindful-movement practice is based on an active range of motion and on PNF patterns of the upper extremities. PNF is a concept of treatment that promotes movement around a series of joints in three planes to achieve spiral and diagonal movements (105, 106). Participants lay supine and practised nine mindful-movement positions of the non-dominant arm consisting of active movement of the fingers, wrist, elbow, and shoulder following the PNF patterns: 1) finger flexion/extension, 2) wrist flexion/extension, 3) elbow pronation/supination, 4) elbow flexion/extension, 5) shoulder flexion/extension, 6) shoulder abduction/adduction, 7) shoulder internal/external rotation, 8) PNF pattern of shoulder flexion-abduction-external rotation (D1F) and shoulder extension-adduction-internal rotation (D1E), 9) PNF pattern of shoulder flexion-adduction-external rotation (D2F) and shoulder extension-abduction-internal rotation, respectively (D2E) (105).

4.4.5.2 Active control group

Participants in the AC group received and listened to an audiobook about the anatomy of the upper limb (107) for 10 minutes and undertook sitting meditation for 20 minutes. They were guided by a CD for 30 minutes, 3 times a week on non-consecutive days, for 8 weeks and recorded their compliance using a Logbook (Appendix V).

4.4.5.3 Control group

Participants in the control group received no interventions of any kind; they carried on with their daily lives as usual over the eight weeks.

4.4.6 Outcome measures

4.4.6.1 Primary measure: The Jebsen Hand Function Test

The JHFT is a standardised assessment which is used to evaluate the function of the upper limb of both, the dominant and the non-dominant arm. It consists of 7 tasks which simulate activities in everyday life such as gross motor, fine motor, weighted and non-weighted activities (108). The JHFT has been used to evaluate the motor function of the upper extremity at all ages, including children, adults and the elderly, with and without disabilities (108, 109). Available data suggests that the JHFT is an appropriate measure of arm and hand function in the elderly and takes approximately 15 minutes for administration (108). JHFT was selected for measuring the motor performance of the upper limb in chapter 4 and 5. Although JHFT has not yet been used to investigate the effectiveness of meditation in patients with stroke. Participants were asked to perform all tasks and the time taken to complete them was timed by a stopwatch. The time taken for each subtest was summed for the total score with shorter times indicating a better performance (108).

4.4.6.2 Secondary measures: Electroencephalography

The secondary outcomes were cortical motor and attentional functioning from baseline to 8 weeks as tested using EEG (110), only in MMTP and AC groups. Oscillatory activity in the alpha band of the EEG (8-12Hz) was measured over the sensorimotor cortex (sensorimotor or mu rhythm) during an imagined hand and arm movements to assess cortical motor function of the dominant and non-dominant limbs. For this, participants were asked to close their eyes and follow spoken instructions. These were played via a sound file and were identical for all MMTP and AC participants and pre- and post-intervention sessions. Participants were asked to imagine repeated hand and arm movements (e.g. cutting with scissors, moving a curtain) for 15 minutes during which their EEG was recorded. Dominant and non-dominant limb action instructions were alternated. More effective sensorimotor functioning is indicated by greater mu alpha blocking (less oscillatory mu alpha activity) (101-103).

The sensorimotor attentional function was measured by assessing the P300 component of the somatosensory ERPs in response to tactile stimuli on the dominant and non-dominant hands in a tactile oddball task. Whenever a current was passed through a solenoid stimulator, a tactile controller (Heijo Research Electronics, London, UK) delivered suprathreshold mechanical taps by pushing a blunt plastic tip against the participant's index fingertip. Two different kinds of tactile stimuli were presented: taps (three 2-ms depressions of the skin separated by 47-ms intervals) and buzzes (twenty 2-ms depressions of the skin separated by 3-ms intervals). The frequency of taps and buzzes was manipulated, and participants were asked to count the infrequent (oddball) stimuli, indicating their answer after each block. Whether taps or buzzes were infrequent for the first or the second half of all blocks was counterbalanced. Dominant and non-dominant hands were tested in alternating blocks of three, always starting with the dominant hand. In total there were 12 blocks of 50 tactile stimuli, of which between 4 and 17 (average: 10) were infrequent oddballs. EEG was measured throughout, and feedback on oddball counting accuracy was provided after each block. More effective allocation of attention within the somatosensory system is indicated by more accurate counting of infrequent targets and by higher P300 amplitudes to infrequent compared to frequent stimuli (111, 112).

4.4.6.3 Other outcomes:

Mindfulness, mood, perceived stress and quality of life from baseline to 8 weeks were measured only in MMTP and AC groups using the short-form FMI, the POMS-SF, the PSS-10, and CASP-19.

4.4.6.3.1 The short-form Freiburg Mindfulness Inventory

The short-form FMI is a self-reported questionnaire for measuring mindfulness and is suitable for both non-meditators and meditators. There are 14 items which cover all aspects of mindfulness. Participants indicated how often they characterised the experience of mindfulness in the past week like "I sense my body, whether eating, cooking, cleaning or talking". Each item is rated on a 4-point Likert scales from 1 (rarely) to 4 (almost always), ranging score from 14 to 56. Higher scores indicate more mindfulness. The short-form FMI has good construct validity and high internal consistency reliability (α=.86) (113-115).

4.4.6.3.2 The Profile of Mood States-Short Form

The POMS-SF is a 30-item self-report measure of mood and emotional distress in an older population (116, 117). Its six subscales measure tension/anxiety, depression/dejection, anger/hostility, fatigue/inertia, confusion/bewilderment, vigour/activity, with a total mood score representing overall emotional distress. The total mood score is the sum of all subscales except the score of vigour/activity that needs to be subtracted (116, 118). Participants are asked to indicate their feelings during the past week and today from a list of adjectives that describe feelings of people such as tense, angry, worn out, lively, or confused. It uses a 5-point Likert scale from 0 (not at all) to 4 (extremely) to measure agreement (119). The total scores range from -20 to 100, and lower total scores and lower scores on individual subscales indicate a more positive mood state, except for the vigour/activity subscale (116). POMS-SF has a high internal consistency that ranged from 0.76 to 0.95 (118).

4.4.6.3.3 The Perceived stress scale

The PSS is a self-assessment questionnaire for measuring the perception of stress (120, 121). The evidence of systematic review of the psychometric properties of the PSS demonstrated that a short version of 10 items (PSS-10) is superior to the original a 14-item scale (PSS-14) (120). Each item is rated on a 5-point Likert scale from 0 (never) to 4 (very often) (120, 121). Participants indicated their feelings and thoughts during the last month both negative and positive questions like "In the last month, how often have you been upset because of something that happened unexpectedly?" or "In the last month, how often have you felt confident about your ability to handle your personal problems?". The PSS-10 total scores range from 0 to 40 by reversing the positive items scores and then summing all scores. A higher score means greater stress (121). The PSS-10 has good internal consistency, reliability and test-retest reliability at > .70 (120).

4.4.6.3.4 The Older People's Quality of Life; Control, Autonomy, Satisfaction, Pleasure-19 items

The CASP-19 is a self-reported questionnaire for measuring the quality of life in the elderly population (122, 123). It is based on a theory that humans need satisfaction and comprises four domains of need: control (4 items), autonomy (5 items), self-realisation (5 items), and pleasure (5 items) (122-124). There are 19 items, in each item with a 4-point Likert scale from 0 (often) to 3 (never). Participants answered questions "how often they feel" about their lives like "I feel that what happens to me is out of my control" (negative statement) or "I feel that my life has meaning" (positive statement). The total score ranges from 0 to 57 by reversing of positive questions and then summing up the total scores. The higher scores demonstrate better quality of life (123, 124). The CASP-19 has high validity (r=0.6) and internal consistency in the domain of control (Cronbach's alpha=0.59), autonomy (Cronbach's alpha=0.67), self-realization (Cronbach's alpha=0.77), pleasure (Cronbach's alpha=0.74) (122, 123).

4.4.7 Statistical analysis

The Statistical Package for the Social Sciences (SPSS23) for windows was used for data analysis in this study. Descriptive statistics were used for parameter measurement and comparison baseline measures of all groups. The Kolmogorov-Smirnov test was used for monitoring the normality of each measured outcome. The primary outcome was changes in JHFT during eight weeks. Kruskal Wallis test was used to compare JHFT between groups. The secondary outcomes included changes in EEG/ERP measures (mu alpha power; P300 amplitude), attentional performance, FMI, POMS-SF, PSS-10, and CASP-19 over eight weeks. Paired t-tests were used to compare variables within the group and the independent t-test used to compare variables between groups. Repeated-measures ANOVAs were used to measure JHFT, mu alpha power, and attentional performance in the tactile oddball task and in somatosensory P300s for the within-subject factors session (pre- versus post-test) and hand (non-dominant versus dominant hand) and the between-subject factor group. Pearson correlation coefficient was used to measure the linear correlation between mu alpha power / P300 amplitude and JHFT. The significance criterion was set at $p \leq 0.05$ for all the tests.

4.4.8 EEG recording and analysis

Brain electrical activity was recorded continuously using a Hydrocel Geodesic Sensor Net consisting of 128 the silver/silver chloride (Ag–AgCl) electrodes across the scalp and referenced to the vertex. EEG was amplified with a 0.1 to 100 Hz band-pass filter and digitised at 500 Hz. Off-line analysis was conducted using NetStation 4.5.1 analysis software (Electrical Geodesics Inc.).

To investigate oscillatory activity in the alpha frequency band, continuous EEG data were high-pass filtered at 0.5 Hz and low-pass filtered at 45 Hz using digital elliptical filtering. EEG obtained during left, and right hand and arm movement imagination were respectively segmented into six epochs of 50 seconds each. Bad channels were replaced where necessary. Segments were averaged for each condition of left and right imagined movements and re-referenced to the global average reference. Spectral power in the alpha band was computed using a fast Fourier transform (FFT) approach with Welch-windowed epochs of 1000 ms. Data were extracted between 7.8 and 12.6 Hz (following limited fixed band choices available for extraction within NetStation software) for further analysis. Measurements over sensorimotor electrodes C5 and C6 were averaged, thus containing alpha oscillatory activity from both contra- and ipsilateral sensorimotor cortex (99, 125), for movement imagination of the dominant limb and the non-dominant limb, respectively. Statistical analyses of the oscillatory data were conducted for each limb (dominant versus non-dominant), before and after the intervention in each group (MMTP versus AC groups).

To investigate P300 responses reflecting attentional performance during the tactile oddball task, continuous EEG data were high-pass filtered at 0.1 Hz and low-pass filtered at 30 Hz using digital elliptical filtering and segmented from 100 ms before until 600 ms after tactile stimulus onset. Segments with eye blinks (eye channel voltages exceeding ± 140 µV) were rejected from further analysis. Bad channels (voltages exceeding ± 200 µV) were replaced where necessary. Artifact-free data were then baseline-corrected to the average amplitude of the 100-ms pre-stimulus interval and re-referenced to the average potential over the scalp. Finally, individual and grand averages were calculated for each condition of interest. As long-latency components such as P300 are non-lateralised and have a centroparietal distribution, which reduces and shifts toward frontal regions in older age (126), measurements over central electrodes C5 and C6 were again averaged for analyses. Statistical analyses of the ERP data targeted the examination of stimulus type (frequent versus infrequent tactile stimuli) for each limb (dominant versus non-dominant), before and after the intervention in each group (MMTP versus AC groups).

4.5 Results

4.5.1 Participant flow

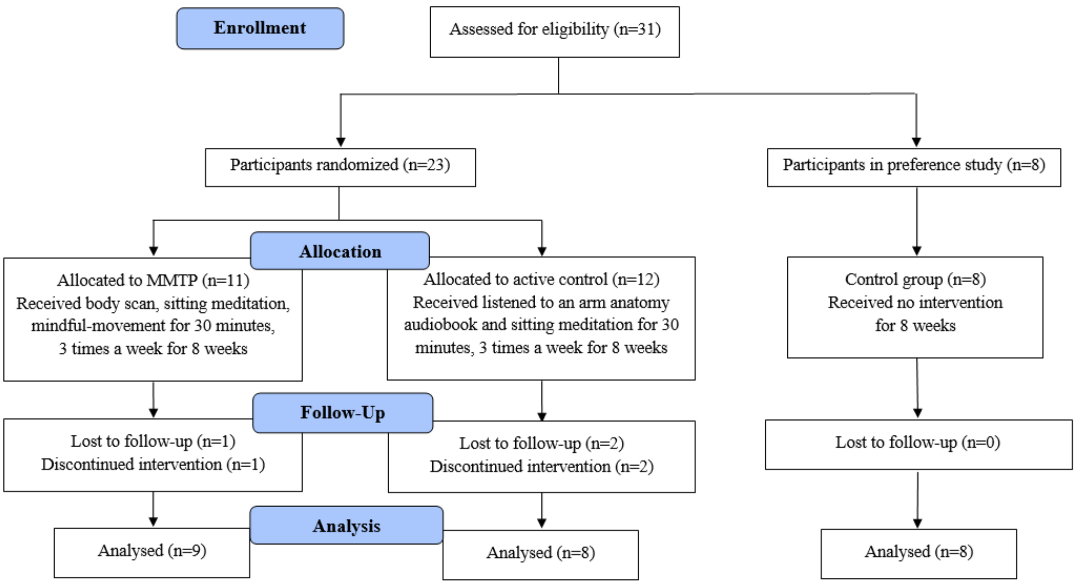

Figure 4. Flow diagram of participants: MMTP compared with active control and control groups of healthy older adults.

4.5.2 Baseline data

In total, 31 participants (51-70 years old) were recruited into the study (Figure 4). After follow-up, there were nine participants in the MMTP group (6 females, 3 males). Their mean age was 60.2±3.1 years (55 to 65 years), and their education level was 15.9±2.8 years. Three of them had practised mindfulness meditation. Two of the participants had depression. Six participants also had other medical conditions; one had back pain, two had thyroid issues, two had hypertension, and one had arthritis. In the AC group, there were eight participants (6 females, 2 males). Their mean age was 61.5±2.9 years (57 to 65 years), and their education level was 15.5±2.9 years. Three of them had practised mindfulness meditation. One participant had depression. Three participants also had other medical conditions; one had back pain, one had knee pain, one had a bladder condition, and one had atrial fibrillation. There were eight participants in the control group (6 females, 2 males) and their mean age was 56.8±7.4 years (51 to 70 years). All participants are right handed. There were no significant differences in the baseline of participants in three groups (Table 4).

Table 4. Baseline demographic and clinical characteristics.

	MMTP	Active control group	Control group
Number of participants	9	8	8
Sex (female)	6 (66.7%)	6 (75%)	6 (75%)
Age (years)	60.2 (3.1)	61.5 (2.9)	56.8 (7.4)
Education level (years)	15.9 (2.8)	15.5 (2.9)	
Meditation experiences (yes)	3 (33.3%)	3 (37.5%)	
Depression history (yes)	2 (22.2%)	1 (12.5%)	

* Data are means (SD) or numbers (%)

4.5.3 Outcomes and estimation

There was no significant difference between the three groups after eight weeks for the JHFT. However, MMTP and AC groups showed significant changes from pre- to post-tests within their respective group (see Table 5). In the MMTP group, there were significant improvements in JHFT performance speed for the non-dominant hand and dominant hand. In the AC group, only the non-dominant hand improved significantly. There were no significant differences in the control group. Furthermore, in the other outcome measures only in the MMTP group demonstrated that there was a significant improvement in the vigour/activity domain of POMS-SF and the total score of POMS-SF. Also, in the MMTP group, the effect size was large (>0.8) for changes in JHFT of both the non-dominant and dominant hands, and was moderate (>0.5) for changes in depression/dejection, vigour/activity, and the total score of the POMS-SF. In the AC group, the effect size was large for changes in JHFT of the non-dominant hand and for changes in anger/hostility of the POMS-SF. Effect sizes were moderate for changes in JHFT of the dominant hand, perceived stress (PSS-10), vigour/activity, the total score of the POMS-SF, and the pleasure domain of the CASP-19 (Table 5).

A repeated measures ANOVA statistically investigated group differences in the effects of pre vs. post JHFT performance for MMTP and AC groups only. There were main effects of session ($F(1,15)=41.7$, $p<0.001$), hand ($F(1,15)=117.6$, $p<0.001$) and an interaction between session and hand ($F(1,15)=19.0$, $p=0.001$). However, neither of them interacted significantly with group (session x group: $F(1,15)<0.1$, $p=0.996$, limb x group: $F(1,15)=0.8$, $p=0.400$, session x limb x group: $F(1,15)=0.7$, $p=0.404$), suggesting that the observed differences between the groups in the effects of their respective interventions on JHFT performance were not confirmed by statistically significant differences in an omnibus ANOVA.

Table 5. Changes in outcomes measure over the eight weeks for each study group.

Outcomes	**MMTP (n=9)**				**Active control group (n=8)**				**Control group (n=8)**			
	Baseline mean (SD)	**8 weeks mean (SD)**	**p-Value**	**ES Cohen's *d***	**Baseline mean (SD)**	**8 weeks mean (SD)**	**p-Value**	**ES Cohen's *d***	**Baseline mean (SD)**	**8 weeks mean (SD)**	**p-Value**	**ES Cohen's *d***
JHFT												
Non-dominant hand	70.57 (12.22)	59.96 (13.32)	0.008**	0.87	67.88 (9.6)	58.61 (7.89)	0.012*	0.97	74.66 (15.84)	68.89 (20.14)	0.123	0.36
Dominant hand	40.06 (2.95)	37.66 (4.37)	0.038*	0.81	41.94 (6.72)	38.18 (4.47)	0.069	0.56	44.58 (8.4)	44.25 (8.31)	0.779	0.04
FMI	41.56 (5.94)	41.67 (6.44)	1.00	0.02	38.63 (3.81)	39.88 (4.73)	0.523	0.33				
PSS-10	14.44 (6.25)	11.44 (5.08)	0.154	0.48	16.88 (6.03)	12.5 (3.59)	0.067	0.73				
POMS-SF												
Tension/anxiety	5.11 (1.96)	4.56 (2.55)	0.394	0.28	3.75 (1.67)	3.13 (2.42)	0.319	0.37				
Depression/dejection	3.11 (1.9)	1.89 (2.03)	0.06	0.64	3 (2.14)	2.38 (2.45)	0.26	0.29				
Anger/hostility	2.44 (2.6)	1.56 (1.94)	0.109	0.34	3.13 (1.36)	2 (1.6)	0.071	0.83				
Fatigue/inertia	6 (3.97)	4.11 (1.83)	0.114	0.48	4.38 (2.88)	4.5 (4.04)	1.00	0.04				
Confusion/bewilderment	3.67 (2.12)	3.22 (1.48)	0.496	0.21	3.13 (1.36)	3.63 (1.51)	0.234	0.37				
Vigour/activity	9.44 (3.57)	11.78 (2.95)	0.02*	0.66	10.5 (1.69)	11.38 (3.07)	0.399	0.52				
Total mood score	10.89 (11.72)	3.56 (8.02)	0.033*	0.63	6.88 (5.03)	4.25 (7.57)	0.159	0.52				
CASP-19												
Control	8.44 (1.59)	8.89 (1.45)	0.351	0.28	8.75 (1.49)	8.5 (1.2)	0.458	0.17				
Autonomy	11.22 (2.22)	11 (1.66)	0.67	0.10	10.63 (2.26)	10.25 (2.55)	0.683	0.17				
Self-realization	11.22 (1.48)	11.11 (1.69)	0.887	0.07	10.75 (2.82)	12.13 (1.13)	0.257	0.49				
Pleasure	13.33 (1.22)	13 (2)	0.581	0.27	12.25 (2.12)	13.38 (1.9)	0.071	0.53				
Total score	44.22 (4.84)	44 (4.92)	0.833	0.05	42.38 (6.44)	44.25 (3.96)	0.128	0.29				

* p-Value < 0.05, ** p-Value < 0.01, JHFT= Jebsen Hand Function Test, FMI= short-form Freiburg Mindfulness Inventory, PSS-10= Perceived stress scale, POMS-SF= Profile of Mood States-Short Form, CASP-19= Older People' s Quality of Life

4.5.3.1 Sensorimotor (mu alpha) oscillations during the imagination of upper limb movements

In the MMTP group, mu alpha decreased significantly from 0.672±0.564 µV to 0.461±0.358 µV (p=0.023) after eight weeks. Mu alpha in the AC group reduced from 0.655±0.393 µV to 0.554±0.234 µV, but this was not a significant difference (p=0.258) (Figure 5).

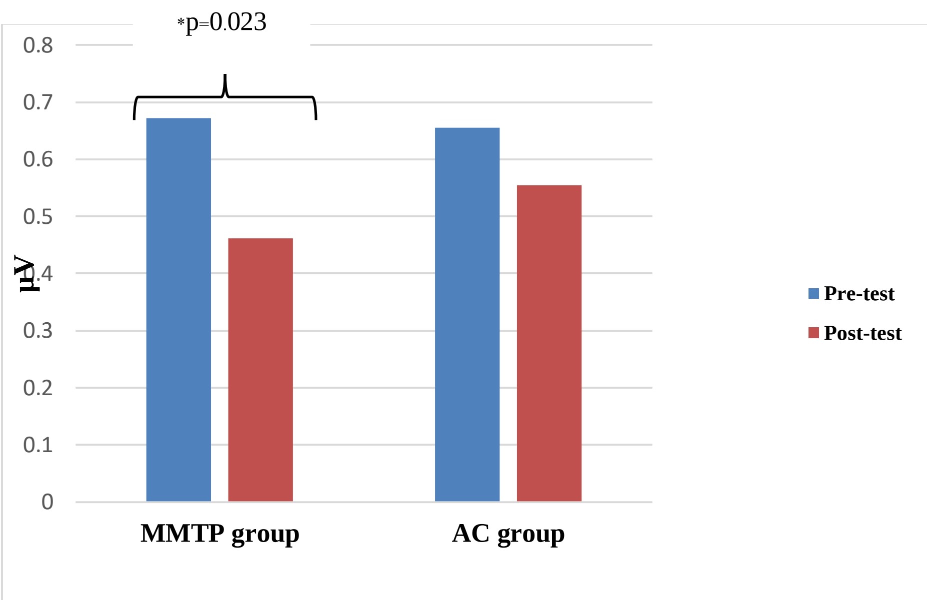

Figure 5. A bar graph showing pre- and post-treatment mu alpha activity for electrode over the hand/arm area of somatosensory cortex (C5/6) in each group.

A repeated-measures ANOVA for the within-subject factors session (pre- versus post-test) and limb (non-dominant versus dominant) and the between-subject factor group showed that there was a significant effect of session ($F(1,15)=7.9$, $p=0.013$), with mu alpha reducing from 0.66 to 0.51 µV at electrode C5/6 overall. This shows an overall greater desynchronisation (blocking) of mu alpha (i.e. more effective sensorimotor functioning) following the interventions. This main effect did not interact with group ($F(1,15)=1.0$, $p=0.341$). The main effect of limb ($F(1,15)=5.5$, $p=0.034$) also showed that there was more mu alpha blocking during the imagination of movements with the non-dominant limb (0.55 µV) than the dominant limb (0.62 µV). This main effect did not interact with group ($F(1,15)=0.5$, $p=0.502$). There was no interaction between session and limb ($F(1,15)=1.6$, $p=0.229$), nor between session, limb and group ($F(1,15)=1.0$, $p=0.330$). This suggests that there were no statistically significant differences between the groups in the effects of their respective interventions on mu alpha blocking. However, planned pairwise comparisons of the estimated marginal means between levels of session showed that there was a significant improvement in mu alpha blocking in the MMTP group only. Mu alpha blocking occurred during the imagination of movement with both the non-dominant limb ($F(1,15)=6.4$, $p=0.023$) and the dominant limb ($F(1,15)=6.7$, $p=0.020$). The same pairwise comparisons for the AC group were not significant ($F(1,15)\leq 2.3$, $p\geq 0.148$). This shows that sensorimotor cortical functioning is improved following MMTP specifically.

We further correlated JHFT performance speed with mu alpha activity. For the MMTP group, there were significant positive correlations between JHFT post-test performance with the non-dominant limb and pre-test mu alpha ($r=.73$, $p=0.025$) as well as post-test mu alpha ($r=.80$, $p=0.010$) obtained during movement imagination with the non-dominant limb. JHFT pre-test performance with the non-dominant limb did not correlate with alpha ($r\leq .56$, $p\geq 0.115$). There was also a correlation between JHFT post-test performance with the dominant limb and post-test alpha ($r=.67$, $p=0.047$), but not pre-test alpha ($r=.52$, $p=0.151$), obtained during movement imagination with the dominant limb. For the AC group, none of the correlations reached significance ($r\leq .52$, $p\geq 0.124$). This shows that effective sensorimotor cortical functioning is related to overt hand function speed in the MMTP group.

4.5.3.2 Attentional performance

Performance in the tactile oddball task was good, with participants' target counting accuracy averaging 97.3 per cent. Accuracy showed slight improvements from pre- to post-tests for both groups, especially for the non-dominant limb in the MMTP group. A repeated-measures ANOVA for the within-subject factors session (pre- versus post-test) and limb (non-dominant versus dominant), and the between-subject factor group showed that there was a marginal effect of session ($F(1,15)=4.4$, $p=0.053$), with accuracy improving from 96.6 per cent to 98.1 per cent overall. There was no main effect of limb ($F(1,15)<0.1$, $p=0.923$) nor an interaction between session and limb ($F(1,15)=1.8$, $p=0.196$). Neither of these effects interacted significantly with group (session x group: $F(1,15)=0.3$, $p=0.575$, limb x group: $F(1,15)=0.7$, $p=0.424$, session x limb x group: $F(1,15)=0.8$, $p=0.378$), suggesting that there were no statistically significant differences between the groups in the effects of their respective interventions on tactile oddball performance. However, pairwise comparisons of the estimated marginal means between levels of session showed that there was a significant improvement in accuracy for the non-dominant limb in the MMTP group only ($F(1,15)=4.9$, $p=0.043$). All other pairwise comparisons were not significant ($F(1,15)\leq2.2$, $p\geq0.159$) (Figure 6). This shows that there was more effective allocation of attention towards the non-dominant limb following the intervention in the MMTP group only.

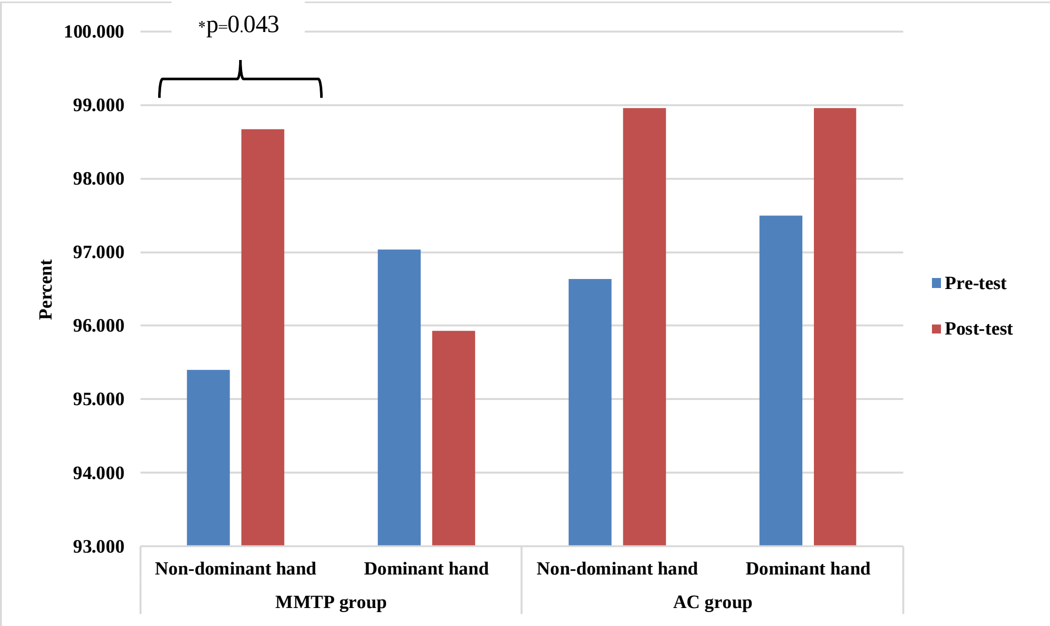

Figure 6. Pre- and post-treatment tactile oddball task performance in each group.

Next, we investigated attentional functioning within the sensorimotor system by measuring differences in the P300 component of the somatosensory ERPs to frequent and infrequent tactile stimuli. Over C6, we detected short to mid-latency somatosensory components P45, N80, P100, N140, P200, N200, and long-latency component P300 in the group averaged waveforms. Only P300 was visible over C5. There were higher P300 amplitudes for the infrequent (to-be-counted oddball) stimuli than for the frequent stimuli in all groups and sessions, indicating the allocation of attention toward targets. To quantify changes in these P300 effects of attention, mean amplitudes were extracted and analysed for a window between 320 and 520 ms after stimulus onset (Figure 7).

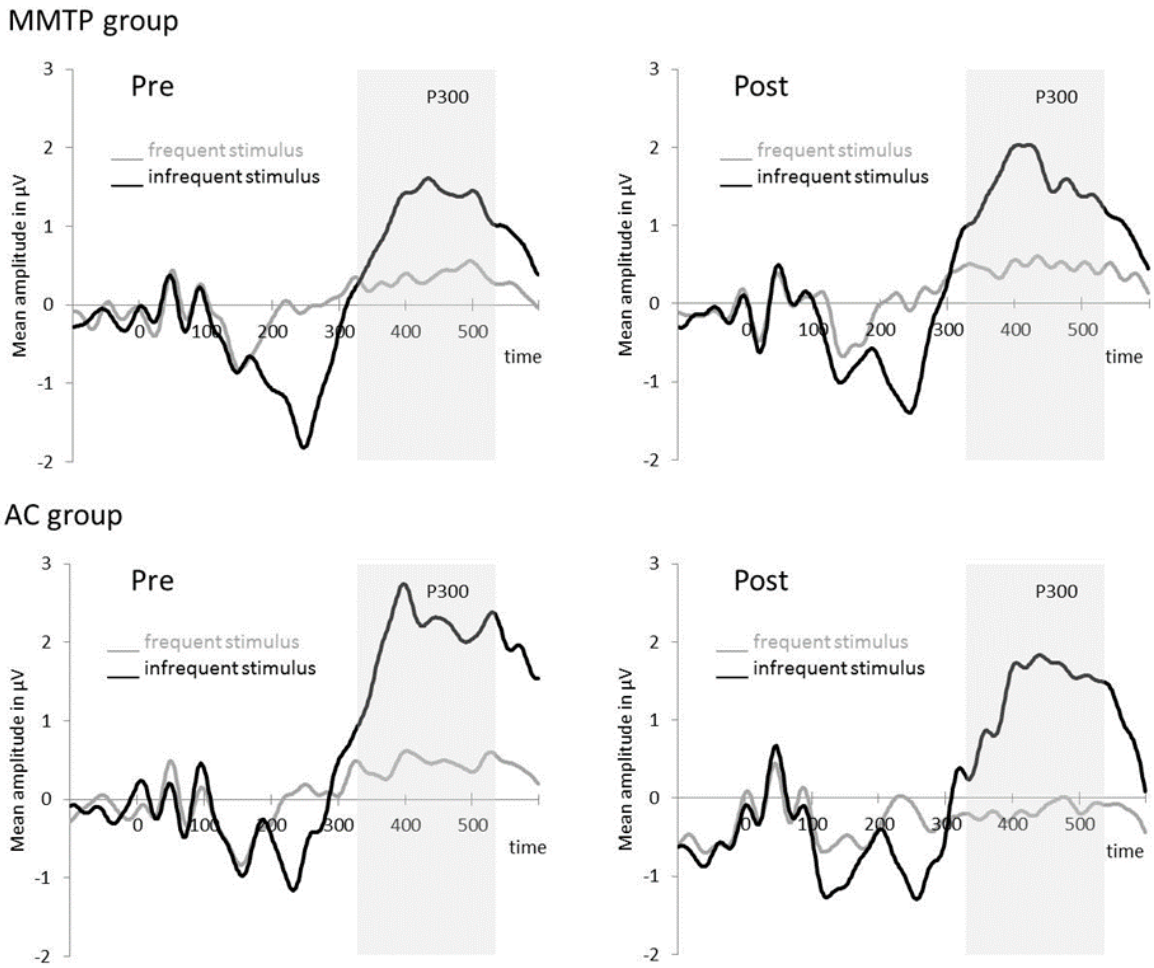

Figure 7. Somatosensory ERP waveforms over C6 showing pre- and post-test P300 to frequent (grey) and infrequent (black) tactile stimuli in each group. Shaded area indicates the P300 analysis window.

Repeated-measures ANOVA for the within-subject factors attention (infrequent versus frequent stimuli), session (pre- versus post-test) and limb (non-dominant versus dominant), and the between-subject factor group, showed that there was a significant overall effect of attention ($F(1,14)=15.4$, $p=0.002$), with larger P300 amplitudes for infrequent than frequent stimuli. This factor did not significantly interact with session, limb, or group (all combinations of interactions $F(1,14)\leq3.1$, $p\geq0.100$), indicating the successful deployment of attention toward targets to comparable extents across all conditions and groups. We calculated attentional effects for each condition of session, limb and group, by subtracting mean P300 amplitudes for frequent stimuli from those for infrequent stimuli. This ANOVA showed no main effect of session ($F(1,14)=3.1$, $p=0.100$), limb ($F(1,14)<0.1$, $p=0.833$), nor an interaction between session and limb ($F(1,14)=0.3$, $p=0.574$), and neither of these effects interacted significantly with group (session x group: $F(1,14)=1.2$, $p=0.292$, limb x group: $F(1,14)=0.3$, $p=0.599$, session x limb x group: $F(1,14)=0.4$, $p=0.518$). This suggests that there were no statistically significant differences between the groups in the effects of their respective interventions on somatosensory P300 effects of attention. However, planned pairwise comparisons of the estimated marginal means for each level of session showed that there was an increase in attention for the non-dominant hand in the MMTP group, which just missed the criterion for significance ($F(1,14)=3.5$, $p=0.083$). All other pairwise comparisons were also not significant ($F(1,14)\leq 1.6$, $p\geq 0.221$).

Pre- and post-test attentional effects over P300 did not correlate with tactile oddball performance or with JHFT performance speed for dominant and non-dominant hands in either group ($r\leq .70$, $p\geq 0.054$).

4.5.4 Harm

There were no adverse events both in the programmes or outcomes measurement in this study.

4.6 Discussion

4.6.1 Feasibility of using MMTP in older adults

The primary purpose of this study was to examine the feasibility of using the MMTP in older adult in order to apply this programme in patients with stroke for rehabilitative training. The study was conducted in older adults aged 51 to 70 years and in intervention groups aged 55 to 65 years. With increasing age, functional deterioration occurs in almost every physiological system (127) and is related to changes in neural structure and function, such as decreasing brain volume, cortical thickness, and cerebral metabolism (75). These complex, age-related changes likely underlie the reduction of attentional, perceptual, and cognitive functions, as well as motor control (128-130). In general terms, age affects the control and organisation of movement, causing a reduction in the speed of movement, a decline in the quality of executed movement, and a loss of fine movement (130). As compared to younger adults, older adults perform more poorly on multiple tests of cognitive performance for this reason (128). Despite the general decline, practice-related improvements can still be found. The results of this study showed that the JHFT improved in both groups especially in the non-dominant hand of the MMTP group. They also had increased sensorimotor cortical functioning as indicated by changes in electrophysiological activity measured over the hand and arm area of somatosensory cortex. Changes in mu alpha desynchronization were found for movement imagination with both non-dominant and dominant hand, indicating that sensorimotor cortical activity was improved throughout. Moreover, there were positive correlations between JHFT for both non-dominant and dominant hand and mu alpha desynchronization during movement imagination with that hand. This shows that changes in brain oscillatory activity over sensorimotor cortex are associated with changes in hand and arm function performance. Furthermore, there was some evidence that attentional performance in a tactile oddball task improved for the non-dominant hand of the MMTP group, providing further evidence for MMTP-related improvements in the sensorimotor system at the level of cognitive control. The results of a systematic review demonstrated that mindfulness meditation interventions for older adults are feasible, they can stop the age-related cognitive decline and perhaps even increase cognitive capabilities in older adults. Mindfulness meditation was found to have a positive effect on attention, processing speed, executive function, and general cognition in older adults (75). Our findings from the presented study confirmed that it is feasible to use MMTP to improve the sensorimotor performance of the upper limbs in the older individuals. We showed that following MMTP, individuals' intention to perform certain actions or perceive certain stimuli activates the underlying cortical correlates more strongly and results in better overt performance. This suggests that the MMTP may have neuroprotective effects and help to reduce the decline in cognitive control related to normal ageing within the sensorimotor system.

4.6.2 Motor performance outcome and sensorimotor oscillations

We found statistically and clinically significant changes in hand motor function as measured by the JHFT, especially in the MMTP group. We further found significant changes in sensorimotor oscillatory activity related to movement imagination. These changes were systematically related to JHFT performance.

Only a few studies have been performed to determine the effect of mindfulness meditation on the motor performance in older adults. The majority of studies integrated mindfulness with exercises such as yoga or tai chi. The recent studies demonstrated that yoga meditation could improve balance, proprioception, and power in older individuals (131) and Buddhism-based walking meditation could improve muscle strength, agility, and balance in elderly individuals with mild-to-moderate depression (132). Our study is the first to demonstrate that MMTP can improve sensorimotor (and attentional) function related to the upper limbs in older adults. We further show, for the first time, the oscillatory neural correlates of this improvement over sensorimotor cortex. For this, mu alpha activity was measured over the sensorimotor regions of the brain that control upper limb movement. Through movement, or simply imagining movement, the amount of activity in the mu alpha range typically reduces (referred to as desynchronization or blocking) (133). Greater reductions thus signify enhanced movement imagination. For electrodes over the hand/arm area of somatosensory cortex, we found that mu alpha reduced from pre- to post-test, and this reduction was greater for the MMTP group than for the AC group, showing that the MMTP was more effective at improving the engagement of this region in movement imagination. Furthermore, mu alpha activity in both pre- and post-tests correlated significantly with JHFT post-test, but not pre-test, especially for the non-dominant hand in the MMTP group. This shows that changes in brain oscillatory activity over sensorimotor cortex are not restricted to movement imagination, but are systematically associated with changes in hand function performance. Specifically, the more mu alpha desynchronisation participants had, the better their sensorimotor cortical engagement related to movement imagination became, and the faster they were at the hand function test after the intervention. This was true for both hands, although effects were somewhat larger for the non-dominant hand.

Mindfulness meditation involves paying attention to present moment experience with an attitude of non-judgmental acceptance, and it is likely that MMTP increased the ability to focus attention resulting in enhanced awareness of physical sensations, perceptions, thoughts and imagery (134). In other words, enhanced awareness of upper limb movements, which were practised in the MMTP but not in the AC group, improved our participants' effectiveness at 'simulating' different, everyday movements with the upper limbs (e.g. cutting with scissors, moving curtains) in their sensorimotor system (133). The likely mechanism for these improvements is neural adaptation as a result of changes in sensory input, motor activity and central (cognitive) processing facilitated by the MMTP. Even the mature adult brain has a great capacity to change, a process referred to as neural 'plasticity' (67). In general terms, MMTP probably facilitates neural plasticity because it provides good-quality sensory input, repetitive movement, and demands approaching one's environment and experience with full attention and awareness. In the following, we will explore the underlying changes in more detail.

Sensory input plays a crucial role in the induction of sensorimotor brain plasticity (135, 136). Much of the available evidence demonstrates that changes in sensory input can alter the excitability of motor cortex (136) and shape primary motor cortex (M1) representations (137). For example, a 15 minutes' period of low amplitude vibration to single intrinsic hand muscles as pure sensory input, remodeled motor cortical hand area. Moreover, these changes were modulated by the attention of participants (138). Mindfulness meditation has been demonstrated to improve attentional control, including the ability to ignore distractions. As it commonly incorporates non-evaluative attention to internal and external stimuli, it should result in a more accurate perception of sensory reality (134). By improving perceptual clarity and attentional control, the body-scan practice can improve the quality of perception related to sensory input. This in turn may affect participants' ability to represent sensorimotor information, which we measured as improvements in JHFT and mu alpha desynchronisations.

The available evidence in the literature confirms that mindfulness meditation can change the structure and function of the brain (21, 23). MMTP may facilitate the neural plasticity that would be ordinarily induced by sensorimotor input (e.g. by moving the upper limbs), and that this is associated with the improved sensorimotor performance found in the MMTP group.

Modifications in the corpus callosum, which can also occur after brief mindfulness meditation, may relate to changes in individual brain regions. Prefrontal structural increases might result in, or alternatively, follow, alterations of particular corpus callosum areas that reciprocally connect bilateral prefrontal gray matter structures. Hypothetically, the increased prefrontal gray matter might in turn require more or larger connective fibres to facilitate communication among, and synchronisation of, regions in opposite hemispheres (21). As a result, changes in one hemisphere can induce brain plasticity in the opposite hemisphere, which may explain why this study found widespread improvements in the motor performance of the upper limb in both non-dominant (trained) and dominant (untrained) hand.

In addition mindful-movement exercise may facilitate the effectiveness of the descending pathway from a broad expanse of the cortex, including primary motor cortex, the premotor cortex, and the postcentral cortex to the brainstem and spinal cord, especially the lateral corticospinal tracts (66, 139). The lateral corticospinal tract comprises of axons from the digit, hand, and arm areas of the M1 (66). Repetitive mindful-movement training may also lead to increase attention to the actual movement of the upper limb during action execution (21) and promote the function of the lateral corticospinal tracts.

In sum, this literature confirms that brief MMTP with a focus on the upper limbs could induce neural plasticity in the areas relating to motor control. The discussed changes in a broad network of brain regions and fibre tracts related to motor control are likely to have improved motor performance of the upper limb in healthy older people in our study. While the cellular mechanisms for inducing structural and functional changes in these brain regions remain unclear, particularly in humans, numerous potential candidate mechanisms have been identified: dendritic branching, synaptogenesis, neurogenesis, angiogenesis, axon sprouting, gliogenesis, fibre reorganisation, myelin formation, myelin remodelling, and astrocyte changes (19, 21). Regardless of the exact mechanisms, the proposed neural changes could account for changes in sensorimotor cortical oscillatory activity reflective of more effective simulation of upper limb movements in the MMTP group than in the AC group, and for JHFT performance improvements for both hands in the MMTP group and for the non-dominant hand only in the AC group.

4.6.3 Attentional performance

Similar to the improved sensorimotor performance described above, overt attentional performance in the tactile oddball task was enhanced from pre -to post-test for the non-dominant hand in the MMTP group only, with improved detection of infrequent tactile targets. This suggests an improved ability to focus on bodily sensations after MMTP, compared to AC, especially for stimuli on the non-dominant hand. There was also some evidence for changes in the underlying cortical correlates related to attentional performance in oddball tasks. The somatosensory P300 is typically larger in response to infrequent tactile targets than frequent tactile standards, indicating attentional selection (111, 112). This index of attentional selection was increased, albeit non-significantly, following MMTP, but not following AC.

Like other mindfulness-based interventions, MMTP comprises FA and OM process. Most mindfulness meditation practices begin with a period of FA on a target, for example, the breath, followed by OM (19, 140). FA practices can be operationalized into their respective attention networks: sustained attention involved concentration of attention on a single object of meditation (e.g. the sensations of the breath) (21, 140), attention switching (e.g. disengaging from distractions), executive attention (e.g. preventing one's focus from wandering), selective attention and attention reorienting (e.g. redirecting focus back to the breath), and working memory (140). Open-monitoring refers to as a broader receptive awareness or 'choiceless' awareness, a capacity to detect events without a specific focus by an unrestricted awareness, instead involve an open, receptive, non-judgmental attitude toward any and all experience, regardless of origin (external/sensory or internal/mental) and affective tone (positive, negative, or neutral). It can include a process of 'meta-awareness' (i.e. awareness of awareness, in which practitioners can reflect on the process of consciousness itself) (21, 140). Attention is often subdivided into three different components: alerting (readiness in preparation for an impending stimulus, which includes tonic effects that result from spending time on a task (vigilance) and phasic effects that are due to brain changes induced by warning signals or targets); orienting (the selection of specific information from multiple sensory stimuli); and conflict monitoring (monitoring and resolution of conflict between computations in different neural areas, also referred to as executive attention). Other distinctions between types of attention refer to combinations of these three components. For example, sustained attention refers to the sense of vigilance during long-continued tasks and may involve both tonics alerting and orienting, whereas selective attention may involve either orienting (when a stimulus is present) or executive function (when the stored information is involved) (19). Overt and covert improvements in the oddball task specifically imply improvements in selective attention. Existing evidence suggests that mindfulness meditation improves attentional performance, processing speed and cognitive flexibility (35). It is, therefore, interesting to see that MMTP was found to increase selective attention. Mindfulness practice improves attentional capabilities and perceptual-cognitive skills. Therefore, practitioners are possibly less distracted, better able to control their attention and place it on goal-relevant aspects, and improve their action orientating (19, 75, 141). Thus there is evidence that mindfulness meditation is associated with changes in attention and perceptual processing circuits, perhaps reflecting the emphasis on conscious direction and redirection of attention to present-moment experience and increased awareness of sensory stimuli (142).

In addition, the body-scan meditation used as part of the MMTP, where the body is focused upon directly or indirectly through present-moment-centred awareness, may have improved perceptual clarity and attentional control, as described earlier (21, 134). This may also have contributed to enhancing tactile acuity and introspective body-awareness. Mindfulness meditation is associated with changes in brain activity involved in attention (35). A recent meta-analysis demonstrated that the anterior cingulate cortex, prefrontal cortex, posterior cingulate cortex, insula, striatum (caudate and putamen) and amygdala are the core regions involved in self-regulation of attention, emotion, and awareness following mindfulness training (19). It is likely that these regions also underlie the observed attentional changes in P300 and overt tactile oddball performance as a result of MMTP, specifically those frontal cortical regions that directly contribute to the functioning of fronto-parietal attention networks (112).

4.6.4 Psychological outcomes

In the MMTP group, the result showed that the vigour/activity domain of POMS-SF and total mood score significantly improved after completion of the programme. Also, moderate clinically significant changes were found in the depression/dejection and the fatigue/inertia domain of the POMS-SF, and in perceived stress as measured by PSS-10. MMTP, which is one of the mindfulness-based approaches, may have contributed to these changes. Recent systematic reviews summarised that mindfulness-based interventions are effective in improving a range of clinical and non-clinical psychological outcomes, including anxiety, depression, stress, mood, and psychological symptoms in patients (70, 143). Even short meditation interventions (e.g., brief body-scan practice) can have significant effects on mood and cognition (134).

The potential mechanisms of how mindfulness beneficially impacts psychological adjustment are through improved attention, experiential acceptance, clarification of values, self-regulation and the regulation of negative emotion, clarity about one's internal life, exposure to an unpleasant experience, flexibility, non-attachment to one's own happiness, and less rumination (141). Therefore, participants are better able to deal with negative emotions including those of inertia, anger, and fear (141). Moreover, several researchers showed that MBSR–related improvements in emotion regulation appear to involve structural and functional changes in the amygdala, a subcortical structure critical for emotional processing (19, 23, 144). The amygdala showed decreased functional activity, improved functional connectivity with the prefrontal cortex, and earlier deactivation after exposure to emotional stimuli (23). Mindfulness meditation practice is thus thought to lead to reduced emotional reactivity by promoting tolerance of emotion and enhanced present-moment awareness (144). As a result, mindfulness meditation is reportedly associated with lowered intensity and frequency of negative affect and improved positive mood states (19). Our findings for the present study confirm that MMTP is also effective in improving mood in healthy older adults.

4.6.5 Mindfulness and Older People's Quality of Life

It is interesting that FMI and CASP-19 did not change after completion of the MMTP. Participants received the MMTP or AC programme as guided by listening to a CD for eight weeks. Standardised mindfulness-based interventions (e.g. MBSR and MBCT) are usually delivered in person by experienced instructors, rather than self-administered (145). Moreover. MBIs are an intensive schedule which teaches weekly for 2 to 2½ hours through a range of formal and informal mindfulness practices (23, 143). The weekly sessions have standardised core elements consisting of different mental and physical mindfulness exercises (145). Five main skills are taught: observing, describing or labelling observations with words, non-reactivity to inner experiences, non-judging of experiences, and acting with awareness. Especially describing, non-reacting, and non-judgment were found to contribute significantly to, and independently mediate, the relationship between mindfulness and well-being (146). In addition to the mindfulness practice, there are teachings (and reflections) on stress, stress management, and how to apply mindfulness to interpersonal communication and everyday situations (145). In addition, participants are encouraged to practice for 30 to 45 minutes daily listening to audiotapes with meditation guided exercises (147). In contrast, MMTP in the present study was practised only for 30 minutes, three times a week. While positive changes were observed in the mood, perceived stress, sensorimotor and attention functions, it is possible that measureable changes in mindfulness and quality of life are only observed after a longer or more intensive programme.

4.7 Limitations

This was a brief intervention study with relatively small sample size. Further studies are required with more participants. Randomised control and preference were used in this study. The study design will form the basis of developing randomised controlled trials and blinded assessment to further evaluate the effectiveness of MMTP in older adults.

4.8 Conclusion

MMTP is feasible to apply in healthy older adults. Both programmes (MMTP and AC) improved the motor performance of the upper limbs in healthy older adults, but improvements were larger and more widespread after MMTP. The programme is easy to implement, with little emotional and physical risk involved. The costs are relatively low due to practice with guided CD, which can be implemented anywhere (e.g., at home). These findings strongly encourage further investigations of the MMTP as a new intervention to improve motor performance in patients with movement disorders such as stroke.

CHAPTER FIVE

THE EFFECT OF A MINDFULNESS MOVEMENT THERAPY PROGRAMME ON THE MOTOR PERFORMANCE OF THE UPPER LIMBS AND MOTOR CORTICAL PLASTICITY IN HEALTHY OLDER ADULTS: A RANDOMIZED SINGLE-BLIND CONTROLLED TRIAL

5.1 Chapter overview

This chapter aims to confirm the effect of MMTP on the motor performance of the upper limb in healthy older adults by improving the research methodology from the previous chapter through increasing the sample size, assessor blinding and measuring brain plasticity with TMS to produce more trustworthy results.

5.2 Rationale

In our earlier study, we proposed and tested the effectiveness of MMTP for improving motor performance of the upper limb in older adults. The results demonstrated that MMTP was feasible and has the potential to improve the motor performance of the trained upper limb, mood, sensorimotor and attentional functioning in older people (148). MMTP is an 8-week programme based on MBSR and MBCT, and includes body scan, sitting meditation, and mindful movement integrated with physiotherapy techniques (148). The body scan may be important for the recovery of the upper limb function (86, 88) because it provides good-quality sensory input. This may help to recover somatosensory deficits as well as increase the excitability of the primary motor cortex (M1), which controls the movement of the hand and arm (86, 136, 137). As demonstrated in the previous chapter we found a more pronounced mu alpha desynchronisation at electrode C5/C6 after MMTP suggesting that participants might have a more effective sensorimotor function affecting planning and movement of the trained upper limb. Sitting meditation has been shown to increase the thickness of the cerebral cortex and synaptic connectivity in the brain areas related to motor control, including the prefrontal cortex, cingulate cortex, thalamus, basal ganglia, hippocampus, and cerebellum (21, 23). Moreover, sitting meditation can increase attention and concentration, by helping meditators to ignore interference from the environment. As demonstrated in the previous chapter, participants in fact had a better attentional functioning after MMTP. As a result, motor performance of the upper limbs might become more effective. In addition, it is recommended that repetitive training of hundreds of times is essential to maximise recovery post stroke (93). Mindful-movement with PNF provides specific patterns and repetitive movement that induce M1 plasticity (20, 52, 148).

To provide further data to confirm the effectiveness of MMTP on the motor performance of the upper limbs, we performed a randomised controlled clinical trial with an increased sample size and a blind assessor in a different cultural context (older Asians). EEG was replaced by TMS for measuring motor cortical plasticity in order to obtain more trustworthy results. Effects of MMTP on mindfulness, anxiety and depression, mood, stress, and quality of life were also measured.

TMS is a non-invasive, harmless, and painless tool (135, 149). It has been used successfully to investigate neuroplasticity that occurred during the recovery of motor function in patients with stroke (136, 150-152). TMS can be used to evaluate cortical excitability, excitatory / inhibitory intracortical circuits, corticospinal tract integrity and provides information about the mechanisms of neuroplasticity (135, 153-155). TMS has been used to evaluate the effectiveness of physical therapy in patients with stroke (156), and Liepert et al. (2000) used TMS to evaluate the effectiveness of constraint-induced movement therapy (CIMT) on cortical plasticity in 13 patients with chronic stroke. However, TMS has not yet been used to evaluate the effectiveness of meditation in patients with stroke.

TMS consists of three main types, single-pulse TMS, paired-pulse TMS, and rTMS (136, 153, 154). Single-pulse TMS is used to evaluate motor cortical excitability and corticospinal tract excitability, which measures motor threshold (MT), motor-evoked potential (MEP), and central motor conduction time (CMCT) (153, 154). MT is the lowest stimulation intensity that elicits MEPs (150, 151, 157), which is closely related to the motor function and is a good predictor for hand motor function recovery in stroke patients (158, 159). MT usually increases in stroke patients due to the disruption of the corticospinal tract (149). Accordingly, MT of the affected hemisphere decreases in patients with stroke during recovery of motor function (151, 159). MEP can be measured by EMG in the muscle of interest (160, 161). The amplitude of the MEP reflects motor cortex excitability, corticospinal tracts integrity, nerve roots excitability and the conduction along the peripheral motor pathway to the muscles (149). The amplitude of the MEP disappears or is decreased due to neuronal or axonal damage (150) after stroke and can be completely absent in patients with a severe stroke and complete paresis (151). MEPs on the affected side are usually smaller than those on the unaffected side (158), and if there is no recovery, MEPs on the unaffected side tend to further increase forming giant MEPs, which contributes to interhemispheric unbalance following stroke (151). In contrast, MEP may reappear or increase with recovery of the motor function (151, 159, 161). CMCT is calculated by the actual time for central motor conduction combined with at least one synaptic delay at the spinal level and time from the proximal root to the intervertebral foramen (149). Demyelination of central motor pathways, loss of large fibers or slow summation of descending excitatory in the corticospinal tract can cause prolonged CMCT (150), while CMCT is positively correlated with the severity of motor function damage (159). Thus, patients with stroke often show an improved CMCT with recovery of motor function (151).

5.3 Objectives

5.3.1 Primary objective:

To investigate the effects of MMTP on motor performance of the upper limbs and cortical motor plasticity in healthy older adults.

5.3.2 Secondary objectives:

To investigate the effects of MMTP on mindfulness, anxiety, depression, mood, stress, and quality of life in healthy older adults.

5.3.3 Specific objectives:

1) To compare the Jebsen Hand Function Test (JHFT) score between and within active control and experimental groups at baseline and week 8.
2) To analyse and compare motor threshold (MT), motor-evoked potential (MEP), and central motor conduction time (CMCT) of single-pulse transcranial magnetic stimulation (TMS) parameters between and within active control and experimental groups at baseline and week 8.
3) To compare the Philadelphia Mindfulness Scale Thai version (PHLMS-TH) between and within active control and experimental groups at baseline and week 8.
4) To compare the Thai Hospital Anxiety and Depression Scale (Thai HADS) between and within active control and experimental groups at baseline and week 8.

5) To compare the Thai Perceived Stress Scale-10 (T-PSS-10) between and within active control and experimental groups at baseline and week 8.
6) To compare the Thai Geriatric Depression Scale (TGDS) between and within active control and experimental groups at baseline and week 8.
7) To compare the Thai abbreviated version of World Health Organization Quality of Life (WHOQOL-BREF-THAI) between and within active control and experimental groups at baseline and week 8.

5.4 Methods

5.4.1 Trial design

The single-blind randomised controlled clinical trial was conducted at the Southern Medical Rehabilitation Center and the Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University, Thailand from July 2017 to December 2017. This study was approved by the Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University, Thailand. The REC number was 60-121-30-2 (Appendix VI).

5.4.2 Participants

Older adults of both genders from Prince of Songkla University and the elderly community in Hatyai, Songkhla, Thailand, were recruited for this study. Participants included were between 55 to 65 years old. Their scores on the Thai version of the mini-mental state examination (MMSE – Thai 2002) needed to be ≥ 14 for those who did not study, ≥ 17 for those who studied in primary school, and ≥ 22 for those who studied at levels beyond primary school. Participants had to pass all five criteria for standardised screening for healthy older adults (see Procedure) and a safety screening questionnaire for TMS (Appendix VII). Participants were excluded if they had: any other neurological illness such as Parkinson's disease, Alzheimer's disease, or stroke, shoulder pain or frozen shoulder, take any drug that might lower seizure threshold including of standard antiepileptic drugs such as phenytoin, phenobarbital, primidone, carbamazepine, valproate and new antiepileptic drug such as lamotrigine, felbamate, gabapentin, tiagabine, vigabatrin, oxcarbazepine, fosphenytoin. All participants provided informed consent before taking part in the study.

5.4.3 Sample size

We used the data from our previous study to calculate sample size via the programme R version 3.3.2. Therefore, the participant sample should contain 20 subjects per group (162) plus 10 per cent to allow for drop out. Forty-four older adults were divided into two groups including 22 in the active control and 22 in the experimental group.

5.4.4 Randomisation

If participants met the criteria for inclusion, they were placed at random by a computer-generating block of random numbers and stratified by age, gender, education level, and experiences of meditation into either active control group or experimental group.

5.4.5 Intervention

5.4.5.1 Mindfulness movement therapy programme group

Participants received 1) body scan of the non-dominant upper limb for 10 minutes, 2) sitting meditation for 10 minutes, and 3) mindful-movement of the non-dominant upper limb for 10 minutes. After baseline assessment, participants received a description of MMTP and were trained in 9 positions of mindful-movement until they were able to do it accurately. After that, participants were guided by CD at home for 30 minutes, three times a week on non-consecutive days, for eight weeks. Compliance was recorded using a Logbook (Appendix VIII).

5.4.5.2 Active control group

Participants received 1) listening to music for 10 minutes, 2) relaxation technique for 10 minutes and 3) swing arm exercise for 10 minutes. After the baseline assessment, participants received a description of these programmes and were trained in swing arm exercise until they were able to do it accurately. After that, participants were guided by CD at home for 30 minutes, three times a week on non-consecutive days, for eight weeks. Compliance was recorded using a Logbook (Appendix IX).

5.4.6 Outcome measures

5.4.6.1 Primary measure:

5.4.6.1.2 The Jebsen Hand Function Test

JHFT is a standardised assessment used to assess dominant and non-dominant upper limb function. A stopwatch was used to record the time of all JHFT subtest activities. The total score was the sum of the time taken for each subtest, rounded to the nearest second. Shorter times indicate better motor performance. The test is simple to manage and requires approximately 15 minutes (108). The JHFT has demonstrated excellent test-retest reliability (163), inter-rater reliability, and intra-rater reliability (108).

5.4.6.1.2 Transcranial magnetic stimulation

Single-pulse TMS was used to measure motor thresholds (MT), motor evoked potentials (MEP), and central motor conduction times (CMCT). TMS was applied using a Magstim Rapid^2 through a figure of eight focal coil. Participants sat on a relaxation chair. A pillow was placed on their lap for their hands to rest on and their elbows were semi-flexed and pronated. They wore a tightly fitting swimming caps for marking the site of stimulation (164, 165). During stimulation, participants were asked to keep their eyes open and remain alert (166). Surface EMG was recorded from first dorsal interosseous (FDI) muscle bilaterally, using silver/silver chloride (Ag–AgCl) disc electrodes attached in a belly-tendon montage (158, 164, 166). To stimulate the M1 area that controls the movement of the FDI muscles the centre of the coil was initially placed with the handle pointing posteriorly and laterally at a 45° angle away from the centre line (165). Then the coil was gradually moved in the step of 0.5 cm until we found the position with the lowest intensity of stimulation, but the largest amplitude MEPs of the FDI muscle. This position is commonly referred to as the hotspot (165, 167). We marked the hotspot on the swimming cap to make sure the same position for measuring throughout the session and post-test in week 8 (165). We measured the hotspot for both hemispheres/hands. MT was measured while the FDI muscles were at rest (RMT). The RMT is characterised as the lowest stimulation intensity required for creating an MEP with peak-to-peak amplitude in the resting target muscle of 50 µV in five out of ten trials (157, 164, 165). The MEP was measured via EMG of the FDI muscle at rest (168, 169) by using an intensity of stimulation equal to the RMT value. Each set of MEPs were averaged, and a peak-to-peak amplitude of MEP was calculated (170). The CMCT was measured by subtracting the latency of cervical responses from the latency of MEPs to cortical stimulation in millisecond

(150). Cervical responses were measured by placing the coil on spinous process of the 7th cervical vertebra, releasing the magnetic waves to produce a MEP, which is accompanied by a latency value.

5.4.6.2 Secondary measures:

5.4.6.2.1 The Philadelphia Mindfulness Scale Thai version

This study was conducted in Thailand. It was necessary to replace the FMI by an assessment available in Thai language. While there is a Thai version of the Philadelphia Mindfulness Scale available, which is a self-report questionnaire measuring the level of mindfulness, we replaced the FMI by the PHLMS-TH. It consists of 20 items and assesses two domains of mindfulness: present-moment awareness (10 items) and acceptance (10 items). Participants indicated how often they had this experience in the past week for a range of statements related to present-moment awareness like "I am aware of thoughts I'm having when my mood changes" and acceptance like "There are things I try not to think about". Each item is scored on a 5-point Likert scale from 1 (never) to 5 (very often), such that each domain had a maximum score of 50, with a total of 100, and higher scores indicating a higher overall state of mindfulness, present-moment awareness and acceptance (171, 172). The PHLMS-TH has a high test-retest reliability and a high internal consistency for the awareness subscale (0.88 and 0.87) and the acceptance subscale (0.89 and 0.88) (172).

5.4.6.2.2 The Thai Hospital Anxiety and Depression Scale

The Thai HADS is a self-report questionnaire for evaluating anxiety and depression. There are 14 items, in each item with 4-point Likert scales ranging from 0 (not at all) to 3 (most of the time). Participants answered questions about their feelings during the past week like "I feel tense or 'wound up'" (anxiety) and "I feel as if I am slowed down" (depression). Positive questions were reverse scored before the scored were combined. The maximum score in each domain was 21, and the total score was 42, with a higher score on each subscale or total indicating greater anxiety and depression. The interpretation of the domain scores ranges from normal (score of 0 to 7, to borderline abnormal (score of 8 to 10), to abnormal (score of 11 to 21) (34).

5.4.6.2.3 The Thai Geriatric Depression Scale

TGDS is a self-report questionnaire used for assessing depression in older adults specifically. There are 30 items participants answer with yes or no, asking about their feelings, behaviours, and thoughts in the previous week like "Are you happy with your life now?". The maximum TGDS score is 30, with higher scores indicating greater depression. The interpretation of the scores ranges from normal (scores 0-9), to mild depression (10-19), to severe depression (20-30). The validity of the TGDS has been found to be excellent at 0.93 (173).

5.4.6.2.4 The Thai Perceived Stress Scale-10

The PSS is a self-report questionnaire for assessing mental stress (120). A short version with ten items (PSS-10) was developed from the original PSS with 14 items, which evaluate perceived stress by asking participants for their feelings and thoughts in the past month like "In the last month, how often have you been upset because of something that happened unexpectedly?" (121). Each item is graded on a 5-point Likert scales rating from 0 (never) to 4 (almost always). Positive questions were reverse scored before the scored were combined. The maximum PPS-10 score was 40, with higher scores indicating higher perceived stress (120). Interpretation of scores is normal around 13 and high stress 20 or more (120). The PSS-10 has been shown to have high internal consistency, reliability and test-retest reliability (> .70) (120).

5.4.6.2.6 The Thai abbreviated version of World Health Organization Quality of Life

The WHOQOL-BREF-THAI is a self-report questionnaire for assessing the quality of life. There are 26 items, with 24 items divided into four domains: physical (7 items), psychological (6 items), social (3 items), and environmental (8 items) quality of life, and with the remaining two items asking about the general quality of life and health-related quality of life. Each item is scored on a 5-point Likert scale from 1 (never) to 5 (the most), yielding a maximum total score of 130, with higher scores in each domain and a higher total score indicating better perceived quality of life. The interpretation of the total scores ranges from poor quality of life (scores 26 to 60) to moderate quality of life (61 to 95) to good quality of life (96 to 130) (174).

5.4.7 Procedure

Older adults were recruited from the Prince of Songkla University and elderly community in Hatyai by leaflet and word-of-mouth. Researcher screened and recruited eligible participants to this study. Participants were then asked to provide informed consent. Then, older adults were assessed with a healthy elderly screening questionnaire. Five domains were screened: 1) healthy body (ensuring that participants did not have any disease or health condition, or that they can control conditions such as hypertension or diabetes) and healthy mind (assessed according to Thai Mental Health Index Screening, TMHI-15), 2) having at least 20 teeth with four pairs of teeth making good contact, 3) having a normal body mass index, 4) being able to help themselves and others, and 5) exercising at least three times a week for 15 to 30 minutes. After that, eligible participants were placed into either active control or experimental group at random, allocated by a computer generating blocks of random numbers.

Participants were measured for both brain function and clinical evaluations at the Department of Physical Therapy and Southern Medical Rehabilitation Centre, Faculty of Medicine, Prince of Songkla University. Motor cortical functions were tested by single-pulse TMS including MT, MEP, and CMCT. Clinical evaluations included JHFT, PHLMS-TH, Thai HADS, T-PSS-10, TGDS, and WHOQOL-BREF-THAI. They were measured by a blind assessor who is a neuro-physiotherapist in Songklanagarind Hospital, Faculty of Medicine, Prince of Songkla University. Then, the researcher explained and trained participants according to their programme, and gave them a log book to record their commitment to practising throughout the programme. The experimental group received the MMTP including body scan, sitting meditation, and mindful-movement. The active control group received the programme of listening to music, relaxation technique, and swing arm exercise. They practised guided by listening to a CD at home for 30 minutes, three times a week on non-consecutive days, for eight weeks and recorded their compliance using the Logbook. Participants who were allocated to the active control group were offered the opportunity to learn and practice MMTP once they had completed the study. Each week, the researcher called or sent a message to participants asking if they had any problems and reminding them to record in their log book. After eight weeks, participants were measured for all outcomes again.

5.4.8 Statistical analysis

The SPSS23 for windows was used for data analysis in this study. Descriptive statistics were used for parameter measurement and comparison of baseline measures in both groups. The Kolmogorov-Smirnov test was used for monitoring the normality of each measured outcome. Paired t-test was used to compare variables within the group, and independent t-test was used to compare variables between groups. Pearson correlation coefficient was used to measure the linear correlation between JHFT and TMS parameters. Repeated-measures ANOVAs were used to measure MT, MEP, and CMCT for the within-subject factors session (pre- versus post-test) and hand (non-dominant versus dominant hand) and the between-subject factor group. The significance criterion was set at $p \leq 0.05$ for all the tests.

5.5 Results

5.5.1 Participant flow

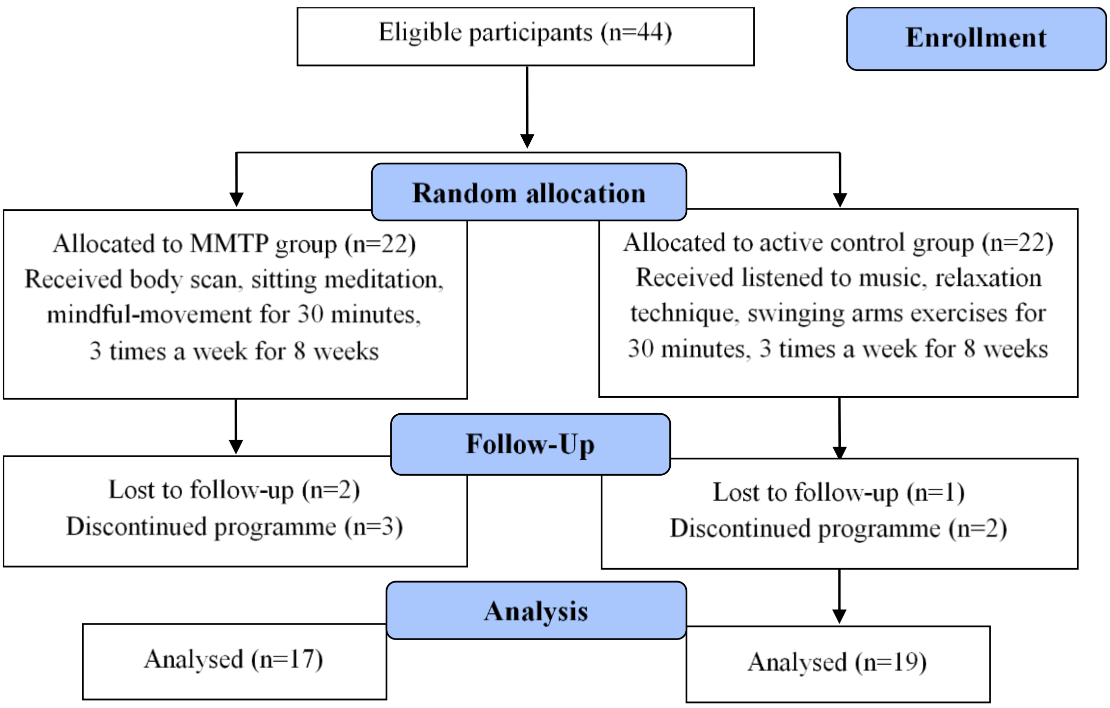

Figure 8. Flow diagram of participants: MMTP compared with active control group of healthy older adults.

5.5.2 Baseline measures

In total, 44 participants (55-65 years old) were recruited into the study (Figure 8), and eight participants dropped out. Therefore, 36 participants remained in the sample. In the MMTP group, 2 participants lost contact, one travelled to aboard, and two could not arrange the time to practice, such that in the remaining sample there were 17 participants (16 females, 1 male). The mean age was 58.12±2.93 years (55 to 65 years). Education was 14.47±3.71 years, and MMSE was 28.53±1.94. Ten of them had practised mindfulness meditation previously. Ten participants had controlled medical conditions; 4 had hypertension, 4 had hyperlipidemia, 1 had diabetes mellitus, and 1 had upper trapezius myofascial pain. In the active control group, 1 participant lost contact, and two could not arrange the time to practice, such that in the remaining sample there were 19 participants (18 females, 1 male). The mean age was 57.31±2.38 years (55 to 64 years). Education was 15.47±2.48 years, and MMSE was 28.79±1.44. Eleven of them had practised mindfulness meditation previously. Twelve participants had controlled medical conditions; 4 had hypertension, 9 had hyperlipidemia, 1 had diabetes mellitus, 1 had asthma, and 1 had knee pain. There were no significant differences in the baseline measures between groups (Table 6).

Table 6 Baseline demographic and clinical characteristics.

	MMTP (n=17)	**Active control group (n=19)**	**p-value**
Sex (female)	16 (94.12%)	18 (94.74%)	0.94
Age (years)	58.12 (2.93)	57.31 (2.38)	0.37
Education (years)	14.47 (3.71)	15.47 (2.48)	0.34
MMSE	28.53 (1.94)	28.79 (1.44)	0.65
Meditation experiences (yes)	10 (58.82%)	11 (57.89%)	0.96

* Data are means (SD) or numbers (%)

5.5.3 Outcomes and estimation

Table 7 below shows the differences between pre- and post-tests for each group, as well as between the groups at post-test. The MMTP group showed significant improvements in right-hemisphere CMCT from pre-test (37.22±5.31m/s) to post-test (43.59±13.11m/s) ($p=0.018$) with moderate effect size (Cohen's $d=0.64$). The same comparison was not significant in the active control group. There was also some evidence for a difference in right-hemisphere CMCT between groups at post-test, which did not quite reach significance ($p=0.08$) but had a moderate effect size (Hedges' $g=0.62$). Other outcomes related to cortical motor function were not significant within or between the groups, except for a significant increase in right-hemisphere MT from pre- to post-test in the active control group ($p=0.036$). However, both groups showed significant improvement in JHFT performance speed from pre- to post-tests within their groups. These differences were especially prominent in the MMTP group; JHFT performance speed for the non-dominant hand improved from 83.45±14.86 to 68.04±13.09 ($p<0.0001$) with a large effect size (Cohen's $d=1.1$), and performance speed for the dominant hand improved from 52.56±10.59 to 46.67±10.2 ($p<0.0001$) with a moderate effect size (Cohen's $d=0.57$). In the active control group, there were significant improvements in JHFT performance speed for the non-dominant hand ($p<0.001$) and dominant hand ($p=0.007$), with the moderate effect size for the non-dominant hand only (Cohen's $d=0.61$).

There was no significant correlation between JHFT performance speed for the non-dominant hand or dominant hand and MT, MEP, or CMCT measures in the contralateral and ipsilateral hemisphere after eight weeks of the programme in both groups. There was no interaction between pre- vs post-test CMCT results and patient group for the left hemeisphere ($F(1,32)=0.6$, $p=0.450$), while in contrast, a significant interaction was found for the right hemeisphere ($F(1,32)=8.0$, $p=0.008$) resulting from a significant difference in the pre- and post-treatment CMCT measueres of the MMTP group ($p=0.002$), and no difference in the active control group ($p=0.531$).

Finally, in the active control group, there was a significant improvement from pre- to post-test in T-PSS-10 ($p=0.042$) with a moderate effect size (Cohen's $d=0.54$).

5.5.4 Harm

No adverse events were observed both in the programmes or during outcome measurement in this study.

Table 7. Changes in outcomes measure over the eight weeks for each study group.

No.	Variables	MMTP group (n=17)			Effect size (Cohen's *d*)	Active control group (n=19)			Effect size (Cohen's *d*)	p-value (between groups at post-test)	Effect size (between groups at post-test) (Hedges' *g*)
		Pre-test Mean (SD)	Post-test Mean (SD)	p-value		Pre-test Mean (SD)	Post-test Mean (SD)	p-value			
1.	JHFT										
	Non-dominant	83.45(14.86)	68.04(13.09)	<0.0001**	1.1	76.54(20.09)	65.55(15.92)	<0.0001**	0.61	0.614	0.17
	Dominant	52.56(10.59)	46.67(10.2)	<0.0001**	0.57	49.77(11.9)	44.77(10.53)	0.007**	0.45	0.587	0.18
2.	MT										
	Lt.hemisphere	83.56(13.21)	79.19(11.95)	0.138	0.35	80.89(10.59)	81(12.04)	0.926	0.01	0.663	0.15
	Rt.hemisphere	83.75(12.9)	82.06(14.29)	0.143	0.12	79.89(12.07)	84.17(12.5)	0.036*	0.35	0.65	0.16
3.	MEP										
	Lt.hemisphere	263.48(154.32)	251.4(120.13)	0.751	0.09	252.05(119.88)	201.87(111.98)	0.139	0.43	0.222	0.43
	Rt.hemisphere	281.6(163.29)	219.68(114.45)	0.088	0.44	229.87(91.74)	211.01(72.88)	0.375	0.23	0.792	0.09
4.	CMCT										
	Lt.hemisphere	39.68(5.66)	38.83(6.05)	0.702	0.15	40.34(9)	42.4(9.02)	0.504	0.23	0.19	0.46
	Rt.hemisphere	37.22(5.31)	43.59(13.11)	0.018*	0.64	38.92(5.75)	37.76(3.74)	0.394	0.24	0.08	0.62
5.	PHLMS										
	Awareness	36.94(5.98)	36.53(5)	0.783	0.07	36.53(6.65)	37.16(7.81)	0.595	0.09	0.778	0.09
	Acceptance	31.06(5.06)	31(5.86)	0.971	0.01	31.98(6.34)	34.21(7.98)	0.211	0.31	0.182	0.45
	Total	68(5.14)	67.53(5.47)	0.757	0.09	68.42(6.99)	71.37(10.37)	0.091	0.33	0.181	0.46
6.	HADS										
	Anxiety	3.71(1.96)	3.65(1.87)	0.906	0.03	3.53(1.84)	3.42(2.59)	0.755	0.05	0.768	0.1
	Depression	1.82(1.85)	1.47(1.66)	0.269	0.2	1.84(1.46)	1.58(1.39)	0.35	0.18	0.833	0.07
	Total	5.53(3.26)	5.12(3.2)	0.53	0.13	5.37(2.43)	5(3.38)	0.463	0.13	0.916	0.04
7.	PSS	12.88(3.53)	10.88(4.95)	0.14	0.47	10.95(4.26)	8.58(4.56)	0.042*	0.54	0.155	0.48
8.	TGDS	2.47(2.1)	2.41(2.48)	0.854	0.03	2.16(1.86)	1.68(1.8)	0.216	0.26	0.315	0.34
9.	WHOQOL										
	Physical	26.71(2.76)	27.12(2.03)	0.507	0.17	27.89(2.15)	28.16(2.69)	0.478	0.11	0.203	0.43
	Psychological	22.82(1.94)	21.94(2.08)	0.114	0.44	23.21(1.47)	26.68(11.86)	0.226	0.41	0.114	0.54
	Social	11.88(1.54)	11.53(1.62)	0.163	0.22	11.63(1.42)	11.84(1.8)	0.57	0.13	0.59	0.18
	Environment	31.65(4.69)	31.24(4.04)	0.503	0.09	31.58(2.69)	32.47(4.17)	0.132	0.25	0.373	0.3
	Total	100.76(9.15)	99.47(8.9)	0.374	0.14	102.32(5.92)	107.37(15.41)	0.116	0.43	0.073	0.62

* p-Value < 0.05, ** p-Value < 0.01, JHFT; Jebsen Hand Function Test, MT; Motor threshold, MEP; Motor-evoked potential, CMCT; Central motor conduction time, PHLMS; Philadelphia Mindfulness Scale, HADS; Hospital Anxiety and Depression Scale, PSS; Perceived Stress Scale, TGDS; Thai Geriatric Depression Scale, WHOQOL; World Health Organization Quality of Life.

5.6 Discussion

5.6.1 Feasibility of using MMTP in healthy older adults

We found that both groups had statistically and clinically significant improvement in motor performance speed as measured by the JHFT, and these changes were especially prominent in the trained hand of the MMTP group. Moreover, there was some evidence for differences between the groups at post-test in CMCT of the right hemisphere, resulting from significant improvements in right-hemisphere CMCT within the MMTP group, which were not mirrored in the active control group. These findings confirm the previous study's suggestion that MMTP training is feasible for improving motor performance of the upper limbs in healthy older adults. The results also suggest that the physiological underpinnings of these improvements might include an increased velocity of signal conduction from the primary motor cortex (M1) of the right hemisphere to the left (non-dominant) hand.

5.6.2 Motor performance

In this study, motor performance was measured by the JHFT in healthy older adults, aged between 55 to 65 years. The baseline of JHFT performance speeds in this study and the previous study (chapter 4) was close to the norm for adults aged 60 to 69 years (108). For the non-dominant hand in this study and the previous study, speeds were 83.45 seconds and 70.57 seconds in the MMTP group, and 76.54 seconds and 67.88 seconds in the active control group, which is approximately similar to the norm of 71.01 seconds. For the dominant hand, speeds were 52.56 seconds and 40.06 seconds in the MMTP group, and 49.77 seconds and 41.94 seconds in the active control group, which is again approximately similar to the norm of 44.3 seconds. It may be noted that the norm data are closer to our previous study rather than the present study, which may be due to the fact that norm data was derived from Western older individuals and the previous study was conducted on the UK population, while the present study was conducted on a population from Thailand. Moreover, there are similar patterns of improvement in JHFT performance speed after completion of the 8-week programme between this study and the previous study. In the MMTP group, the per cent change of motor performance speed for the non-dominant and dominant hands were 18.47 per cent and 11.21 per cent, respectively, in the present study, which is similar to improvements of 15.03 per cent and 5.99 per cent in the previous study. In the active control group, changes for non-dominant and dominant hands were 14.36 per cent and 10.05 per cent, respectively, in this study, which is similar to 13.66 per cent and 8.97 per cent in the previous study. It was found that that the MMTP groups showed numerically greater improvement than the active control group, and that the trained hand showed numerically greater improvement of motor performance speed than the untrained hand. However, these results must be interpreted with caution. In the previous study, it was found that the per cent changes of JHFT performance speed in the passive control group, who did not receive any programme, were also larger for the non-dominant hand than for the dominant hand (7.73 per cent and 0.74 per cent, respectively). It was hypothesised that it might be due to a practice effect during the second JHFT evaluation, which might be especially large for the non-dominant hand, which operates less at the ceiling than the dominant hand. Nevertheless, the numerical differences obtained in both studies over and above such practice effects provide support for the suggestion that improved motor performance of upper limbs, especially for the non-dominant side, is due to the effectiveness of MMTP.

The potential physiological mechanism for motor performance improvement of the upper limb in healthy older adults resides in neural plasticity and improved attention. Behavioural or movement changes are the result of neural plasticity (175). Existing evidence demonstrates that meditation causes changes in the function and structure of the brain including the brain areas involved in motor control and attention (21, 23). Via these structures and their connections, mindfulness meditation is thought to contribute to increasing awareness and attention to the sensory and motor aspects of movements performed during activity (21). For instance, the prefrontal cortex is an important part of the cognitive control and motor planning by linking cortical sensory systems, motor systems, and many subcortical structures essential for movement and cognition, including thalamus, hippocampus and basal ganglia (176, 177). Anterior cingulate cortex (ACC) and mid-cingulate cortex (MCC) relate to self-control and behavioural adjustment. The insula is linked with self-awareness including the awareness of body posture, movement and sensations, which affect behaviour and motivation (21, 23). The cerebellum plays an important role in controlling of movement, posture, balance, coordination, and learning behaviour of the movement (68, 178, 179). The superior longitudinal fasciculus and corpus callosum are involved in both within and inter- hemispheres communication. Meditation enhances the pre-motor areas of the brain in each hemisphere, then larger connective fibres are also added to stimulate synchronisation and communication between the hemispheres (21). Therefore, meditation can affect not only the motor performance of the trained limb but also the untrained limb in healthy older adults. After completing 8 weeks of MMTP, which is one of the mindfulness-based approaches, we speculate that there is an increase in connectivity within and between those brain areas (20, 21, 52, 53, 65), as well as peripheral improvements in the excitability of the corticospinal tract that receives signals from M1 and sends them to the muscles of the contralateral limbs, which altogether result in improved movement performance (20). The cellular mechanisms that are likely involved in such brain plasticity caused by mindfulness meditation are dendritic branching, axon sprouting, synaptogenesis, neurogenesis, myelinogenesis, gliogenesis, and fibre reorganisation. In addition, it may be that mindfulness meditation is beneficial to the autonomic nervous system and the immune system as a result of neuronal protection, restoration, and inhibition of apoptosis (19, 21).

Existing evidence indicates that neural plasticity depends on various factors including sensory input, repetitive movement, environment and experience (136, 137, 180, 181). The body scan encourages good quality of sensory input (136), which may stimulate and induce M1 plasticity, and result in enhanced motor performance (136, 137). Mindful-movement integrated with active exercises, and PNF patterns which are specific repetitive patterns of activity may have long-lasting effects on neural plasticity and M1 function (135, 137). Mindful-movement may increase the number of synapses per neuron in M1 and the cerebellum (137). These neural plasticity changes may be the underlying physiological components for improving motor performance speed of the upper limb in healthy older adults.

Apart from cortical plasticity, attention may be one of the factors that affect the motor performance of the upper limb in the healthy elderly. According to the results of Chapter 4, MMTP training significantly increased attentional performance in the tactile oddball task in the trained upper limb and increased the amplitude of somatosensory P300 in response to infrequent tactile targets, which indicated that older people who followed this programme had a better attentional selection for bodily information. Moreover, existing evidence suggests that mindfulness meditation has a beneficial effect on attention and processing speed (35), probably due to sitting meditation and mindful movement, which cultivates the ability to concentrate by focusing on the breath or body movement, without getting disturbed by the internal and external environment. Thus, motor performance might improve in older people in the MMTP group because they become better at controlling their attention toward the motor task (19, 75, 141).

Therefore, we propose that neural plasticity in the brain areas that control movement combined with better attention and less environmental distraction improves motor performance speed of the upper limb in healthy older adults.

5.6.3 Central motor conduction time

There was a statistically significant increase in CMCT for the right hemisphere within the MMTP group, with a per cent change at 17.11 per cent. The MMTP group's velocity of nerve impulses from the M1 of the right hemisphere to the left FDI muscle increased by 6.37 m/s after eight weeks of training and was faster than that of the active control group. We suggest that it is as a result of this change that the motor performance speed for the non-dominant limb in the MMTP group had a larger per cent change compared to the dominant limb and to the active control group.

I propose that the improvement of right-hemisphere CMCT is due to brain plasticity including the corticospinal tract. We mentioned above that mindfulness-based approaches can induce neuroplasticity in several brain areas that control movement, due to increased synaptic density and connectivity. Moreover, some researchers reported that meditation affects the corticospinal tract and relate to changes in the grey matter of motor areas of the brain (20). These mechanisms may also improve the velocity of the nerve conduction.

5.6.4 Other outcomes

The other outcomes measured in this study, including self- reported mindfulness, anxiety, depression, perceived stress, mood, and quality of life in healthy older adults were not changed after eight weeks of the MMTP.

The MMTP used in this study was a self-administered programme by listening to a CD at home for 30 minutes a day, three days a week, for eight weeks. The total training time was thus 12 hours, which is considered a short-term effect of meditation. Other mindfulness-based approaches require practice with experienced instructors for 2 hours a week, for eight weeks and a daily home-based practice of 45 minutes with a full day retreat (23, 143, 145). The total training time in these programmes is almost 60 hours, which is considered a long-term effect of meditation (19). Although the effects of short-term and long-term meditation are similar on some areas of the brain, some areas change only with longer meditation. One such area is the amygdala, which is directly related to feelings of stress and anxiety (21, 23). Therefore, it is possible that these variables did not change in our study because the mediation training was too short to lead to measurable reductions in perceived stress and anxiety. In addition, participants in this study were healthy older adults who passed the screening criteria with a healthy elderly questionnaire. Thus, they all had a normal baseline. Therefore, it is possible that ceiling effects prevented the MMTP from improving these outcome measures after eight weeks of training.

5.7 Limitations

This study measured brain plasticity with a single-pulse TMS using a Magstim Rapid^2, which can measure only MT, MEP, and CMCT, but cannot evaluate changes in brain function and structure. If possible, paired-pulse TMS which can measure intracortical inhibition (ICI) and facilitation (ICF) or functional magnetic resonance imaging (fMRI) may be used to measure brain plasticity within central motor structures in further studies. Moreover, the present study measured only the short-term effects of MMTP on motor performance, cortical function and other outcome measures. Thus, the longer-term effect should be investigated in future studies.

5.8 Conclusions

This study confirmed the findings from previous studies that MMTP could improve upper limb motor performance in healthy older adults. Both programmes could increase motor performance speed, but especially MMTP, which increased nerve conduction velocity from the motor cortex to the muscle after completing eight weeks of the programme. Therefore, it is feasible to apply MMTP for improving hand and arm function in patients with stroke.

CHAPTER SIX

THE EFFECT OF A MINDFULNESS MOVEMENT THERAPY PROGRAMME ON ARM AND HAND FUNCTION IN PATIENTS WITH STROKE: A PRELIMINARY STUDY

6.1 Chapter overview

This chapter presents the feasibility of MMTP on arm and hand function in patients with stroke. The study examined the effects of MMTP on upper limb function, impairment, spasticity, mindfulness, anxiety, depression, and quality of life. The results showed that MMTP was a useful multi- dimensional programme that not only contributed to improving arm and hand function but also improved psychological state and led to a better quality of life in stroke patients. The results of this study lead to suggestions for further studies on providing an alternative intervention programme for stroke patients with motor impairments.

6.2 Rationale

Stroke is an immediate loss of brain function due to partial or total obstruction of the cerebral blood flow (CBF), causing at least 24 hours of symptoms or leading to death (1, 182, 183). Stroke is divided into two main categories: ischemic stroke and hemorrhagic stroke (1, 183), and type 3 is TIA which is a warning sign that a stroke may occur with a temporary dysfunction of the nervous system and the symptoms may return to normal within 24 hours (1, 184). Ischemic stroke occurs in approximately 85 per cent, while hemorrhagic stroke occurs in only 15 per cent of strokes (1, 4). Ischemic stroke has three major causes: stenosis due to arterial plaque formation (45 per cent), occlusion due to embolic events (20 per cent) and global ischemia as a result of hypotensive dysregulation (1, 4, 183). While atherosclerosis is the main cause of thrombotic stroke, the most frequent cause of cerebral embolism is atrial fibrillation. Embolism from upper chest and neck arteries, embolism caused by myocardial infarction, heart valve failure, and after cardiac surgery are rare causes of embolic stroke (1, 183). Global cerebral ischemia is caused by a loss of arterial pressure, frequently in the context of systemic hypoperfusion due to cardiac arrest as a result of myocardial infarction, arrhythmia, or severe hypotension (1). Hemorrhagic stroke is the breakdown of blood vessels in the brain (185) and blood flowing into the gaps around the brain cells (1). As a result, there is harm from hypoxia and increased intracranial pressure (ICP). Thus, hemorrhagic stroke is more severe than ischemic stroke (185). There are two types of hemorrhagic stroke: (1) intracerebral hemorrhage caused by hypertension, trauma, bleeding disorders, or vascular abnormalities and (2) subarachnoid hemorrhage caused by aneurysm rupture or bleeding from vascular malformations (1, 4, 183, 185).

Pathophysiology of stroke shows two different areas of hypoperfusion: the ischemic core as an inner layer that is surrounded by the penumbra an as outer layer. In adults, the average CBF is 50 to 55 ml/100g/min. During a cerebral ischemic event, the CBF in the core infarction zone is reduced to ≤ 6 ml/100g/min, resulting in inadequate transport of glucose and oxygen followed by irreversible brain damage with necrosis of both neurons and glia (4, 185). In the penumbra, CBF is approximately 12 to 16 ml/100g/min. This results in abnormal function of neuronal tissue while the structure is preserved and the penumbra may recover if it is reperfused in time (4, 185). Cell death in ischemic regions occurs within a few minutes (1). The process is complex and consists of several subsequent events including (1) energy failure, (2) oxidative stress, (3) excitotoxicity, (4) blood-brain barrier dysfunction and (5) necrosis or apoptosis (1, 4). Limited availability of oxygen and glucose in ischemic regions results in failure of ATP production (1, 185). As a result of this energy breakdown, the ion gradient on the outer cellular membrane is reduced, triggering an inflow of water in neurons, glia cells and endothelial cells. This cytotoxic edema occurs within minutes to hours and is reversible (185). However, if hypoperfusion persists for hours or days, vasogenic edema develops that cannot be restored to its original state. The vasogenic edema is characterised by an increased extracellular fluid volume as a result of increased permeability of endothelial cells to macromolecular serum proteins resulting in an enhanced ICP. The increased pressure compresses neurons, nerve tracts and arteries. If the ICP continues to increase, it may cause persistent ischemia and can lead to cerebral herniation and eventually death (185). Oxidative stress is caused by the imbalance in the formation and removal of free cellular radicals in hypoperfused tissue. Free cellular radicals include hydroxyl radicals (OH), superoxide anions (O^{2-}), nitric oxide (NO) and hydrogen peroxide (H_2O_2). These radicals attack DNA, lipids and proteins and increase the intracellular calcium level. The increase of intracellular calcium interferes with mitochondrial integrity by activating calcium dependent proteins triggering apoptosis (4). Excitotoxicity is caused by excessive excitatory neurotransmitter accumulation and its release to the brain. High intracellular glutamate concentrations may result in an increased Ca^{2+} influx through depolarisation of the cell membrane and thus contribute to an increased intracellular calcium level triggering apoptosis (185). Inflammation induced by free radicals also affects the blood-brain barrier, while a dysfunctional blood-brain barrier contributes to abnormal brain function (4, 186) and eventually neuronal death.

Beside paralysis or weakness directly caused by stroke, stroke patients also have cognitive impairments associated with attention, concentration, orientation, memory, and executive function (183, 187, 188). Muscle weakness leads to a marked decrease in physical activity (188, 189). It is a direct result from reduced signaling from the motor cortex to the muscles via the spinal cord, and it is the cause of slowness in developing force and the delay of initiation and termination of muscle contraction, resulting in impaired motor function and activity of daily living (188). Restoration of motor function after stroke can occur directly by neuroplasticity, which is the ability of the brain to change its function and structure in order to adapt to new situations (89, 92, 190). The human brain is regularly changing throughout its lifespan. Structural neuroplasticity is dominant during fetal development, while neuroplasticity in adults is usually functional. Neuroplasticity after stroke includes synaptogenesis, neurogenesis and changes in gray or white matter density (190). Although structural neuroplasticity occurs rapidly and is more evident within three months or in the acute and subacute phases of stroke, it is the ability for functional neuroplasticity that promotes reorganisation of the neural networks after six months of the onset or in the chronic phase (92, 191).

Mindfulness meditation can induce neuroplasticity (192), and this depends on intervention type, age, handedness and the localisation of the brain lesion (left or right hemisphere, subcortical or cortical) (92). Both, traditional and secular mindfulness techniques can cause significant changes in the function and structure of the brain (21-23, 192, 193) including the brain areas related to control of movement such as the prefrontal cortex, the sensory cortices, the hippocampus, the superior longitudinal fasciculus and the corpus callosum (21, 23, 193).

The results on MMTP demonstrated in chapters 4 and 5 showed that MMTP could improve motor performance in older adults, especially in the trained upper limb. In addition, MMTP enhanced sensorimotor and attentional performance in the brain and increased nerve conduction velocity from the motor cortex, passed through the spinal cord to the muscles. MMTP is a relatively new programme and has not yet been studied in patients with stroke. Thus, we decided for a study design comparing a usual rehabilitation programme with a usual rehabilitation programme plus MMTP. While patients with stroke have limitations in attention, perception and might suffer from fatigue, the programme needed to be adapted from home-based practice to a more individual format with a face to face setting in order to adjust the programme to the individual needs of each patient.

While this study aimed to investigate the feasibility and the effects of MMTP on arm and hand function in patients with stroke, also potential effects on motor cortical excitability, mindfulness, anxiety and depression, spasticity, and quality of life were analysed.

6.3 Objectives

6.3.1 Primary objective:

To investigate the feasible and the effects of MMTP on arm and hand function in patients with stroke.

6.3.2 Secondary objectives:

To investigate the effects of MMTP on neural plasticity in the cortical motor system, impairment of upper extremity, spasticity, mindfulness, anxiety and depression, and quality of life in patients with stroke.

6.3.3 Specific objectives:

1) To compare the Action Research Arm Test (ARAT) score between pre-test 1 (T0), pre-test 2 (T1), and post-test (T2).

2) To analyse and compare motor threshold (MT), motor-evoked potential (MEP), and central motor conduction time (CMCT) of single-pulse TMS between pre-test 1 (T0), pre-test 2 (T1), and post-test (T2).
3) To compare the Fugl-Meyer assessment of the upper extremity (FMA-UE) score between pre-test 1 (T0), pre-test 2 (T1) and post-test (T2).
4) To compare the Modified Ashworth Scale (MAS) score between pre-test 1 (T0), pre-test 2 (T1) and post-test (T2).
5) To compare the Philadelphia Mindfulness Scale Thai version (PHLMS-TH) between pre-test 1 (T0), pre-test 2 (T1) and post-test (T2).
6) To compare the Thai Hospital Anxiety and Depression Scale (Thai HADS) between pre-test 1 (T0), pre-test 2 (T1) and post-test (T2).
7) To compare the Thai Version of the Stroke Impact Scale (SIS) 3.0 between pre-test 1 (T0), pre-test 2 (T1) and post-test (T2).

6.4 Methods

6.4.1 Trial design

A preliminary non-controlled clinical trial analysing pre- and post intervention-effects was conducted at the Southern Medical Rehabilitation Center and the Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University, Thailand from July 2017 to December 2017. The study was approved by the Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University, Thailand. The REC number was 60-135-30-2 (Appendix X).

6.4.2 Participants

Stroke patients of both genders were recruited at the Songklanakarind hospital, Faculty of Medicine, Prince of Songkla University, Thailand. Participants included were between 30 and 70 years of age (56) and had a first unilateral stroke more than six months prior study enrolment. Scores on the MMSE – Thai version 2002 were ≥ 14 for patients who had no education, ≥ 17 for patients who completed primary school and ≥ 22 for patients who completed levels higher than primary school. Participants had to pass a safety-screening questionnaire for TMS and were excluded if they had any other progressively neurodegenerative disease (such as Parkinson's disease or Alzheimer's disease), severe psychotic disease, severe heart disease or increased intracranial pressure. The participants signed consent forms prior to study inclusion.

6.4.3 Sample size

This study was a preliminary trial. Thus, using the sample size cited in the study of Moustgaard et al. (37), approximately ten eligible stroke patients were aimed to be recruited for this study.

6.4.4 Intervention

Participants initially received 4 weeks of standard rehabilitation programme (usual care, control period) followed by 8 weeks of usual care combined with the MMTP consisting of a body scan of the upper extremity in the affected side for 10 minutes, sitting meditation for 10 minutes and mindful-movement of the affected side for 10 minutes. The MMTP was repeated three times a week on non-consecutive days.

6.4.5 Outcome measures

6.4.5.1 Primary measure: The Action Research Arm Test

ARAT was specifically designed for the assessment of upper extremity function and is broadly used in patients with traumatic brain injury or stroke. It uses observation methods for four main subtests including grasp (6 items), grip (4 items), pinch (6 items) and gross arm movement (3 items). It is more suitable for evaluating arm and hand function in patients with stroke than JHFT although it is more time consuming and needs a higher level of cooperation and attention than JHFT. It includes 19 items, and each item is scored on a 4-point ordinal scale from 3 (performed normally) to 2 (completed the test with an abnormality of time or performed with great difficulty) to 1 (performed the test partially) to 0 (could not perform any part of the test). The total score of this test is 57. Importantly, ARAT has a high inter-rater and test-retest reliability (ICC and r > 0.9) (194-198). While ARAT produced more reliable and more detailed results, and the number of patients in the preliminary study was limited, ARAT was chosen over JHFT to asses the effect of MMTP on upper extremity function in patients with stroke.

6.4.5.2 Secondary measures:

Motor cortical plasticity, mindfulness, and anxiety and depression as measured by single-pulse TMS, PHLMS-TH, and Thai HADS were used as described in Chapter 5.

6.4.5.2.1 The Fugl-Meyer Assessment Upper Extremity

The FMA motor scale was developed for measuring changes in motor impairment based on Brunnstrom's concept of sequential stages of motor recovery in patients with stroke (198-200). The motor domain of FMA-UE contains four sections including (A) shoulder/elbow/forearm, (B) wrist, (C) hand, (D) coordination/speed. There are 24 items; each item is scored on a 3-point ordinal scale from 2 (performs fully) to 1 (performs partially) to 0 (cannot perform). The scores range from 0 (hemiplegia) to 66 (normal motor performance). A higher score indicates less impairment (198, 200). The FMA-UE can be assessed within 10 minutes (198), and it has a very high intra-rater (ICC>0.95), inter-rater (ICC=0.97) and test-retest reliability (ICC>0.95) and very high construct validity (0.75) (198-200).

6.4.5.2.2 The Modified Ashworth Scale

The MAS is designed for measuring muscle spasticity and is widely used in clinical and research settings (201, 202). The test is based on the definition of spasticity which is "a velocity-sensitive increase of tonic stretch reflexes" causing resistance to passive movement (202). Each muscle group was tested three times before being scored on a 5-point ordinal scale (203) consisting of 0 (normal tone), 1 ("slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part is moved in flexion or extension"), 2 ("slight increase in muscle tone, manifested by a catch followed by minimal resistance through the remainder (less than half) of the range of motion but the affected part(s) is (are) easily moved"), 3 ("more marked increase in muscle tone through most of the range of movement, but affected part(s) easily moved"), 4 ("considerable increase in muscle tone, passive movement difficult"), and 5 ("affected part(s) is (are) rigid in flexion or extension") (204). The MAS was evaluated at the elbow, wrist, and finger flexors. The inter- and intra-rater reliability of the MAS in patients with stroke is high, especially for the upper extremity (0.84 and 0.83, respectively) (203, 204).

6.4.5.2.3 The Thai Version of the Stroke Impact Scale 3.0

The Thai version of SIS 3.0 is translated from the original SIS 3.0. It contains eight domains, including strength, hand function, the activity of daily living, mobility, communication, emotion, memory/thinking, and participation, with a single item evaluating perceived overall recovery from stroke. Participants answered questions about how stroke has impacted their health and life in the past 1, 2 or 4 weeks depending on the domains like in the past week, "how would you rate the strength of your arm that was most affected by your stroke?". There are 59 items, and each item is scored on 5-point Likert scales, for example, the domain of strength from 5 (a lot of strength) to 1 (no strength at all). The total score is 100, and a higher score indicates a better quality of life. Cronbach's alpha coefficient and test-retest reliability are high (0.9 and >0.9, respectively) (205-207).

6.4.6 Procedure

Patients with stroke were recruited from the Songklanagarind hospital, Faculty of Medicine, Prince of Songkla University, Thailand by leaflet and word-of-mouth. Participants were screened for inclusion and exclusion criteria, and informed consent was retrieved before study entry from all participants. Eligible participants were assigned to the Department of Physical Therapy and Southern Medical Rehabilitation Centre, Faculty of Medicine, Prince of Songkla University for the measurement of all outcomes. An independent neurological physiotherapist employed in the Songklanagarind Hospital, Faculty of Medicine, Prince of Songkla University measured all outcome parameters (single-pulse TMS including MT, MEP, and CMCT and clinical assessment including ARAT, FMA-UE, MAS, PHLMS-TH, Thai HADS and SIS 3.0) to eliminate potential researcher bias from the treatment provider. Before the start of treatment and after completion of 4 weeks of the usual rehabilitation programme participants had their pre-treatment measurements of outcome parameters (pre-test 1 and pre-test 2). Participants then received eight weeks of the usual rehabilitation programme combined with MMTP consisting of body scan, sitting meditation and mindful-movement. The researcher provided MMTP face to face in a comfortable and quiet room three times a week on non-consecutive days. After completion of the 8-week programme, participants had their post-test measurement of outcome parameters (Figure 9).

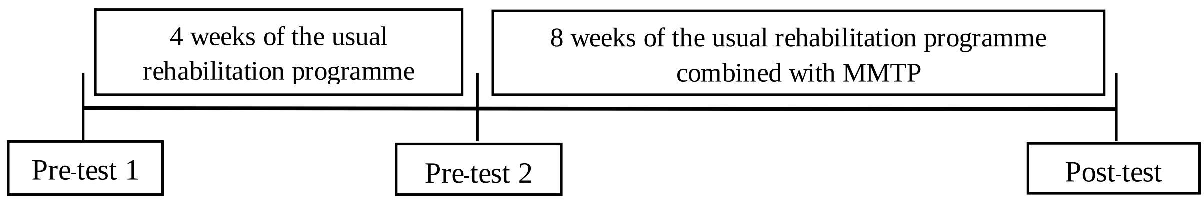

Figure 9. The procedure for the study.

6.4.7 Statistical analysis

The SPSS23 was used for data analysis with descriptive statistics for all parameters assessed. The Wilcoxon signed-rank test was used to compare outcomes over time (T0, T1, and T2). The significance criterion was set at $p \leq 0.05$ for all the tests.

6.5 Results

6.5.1 Trial flow

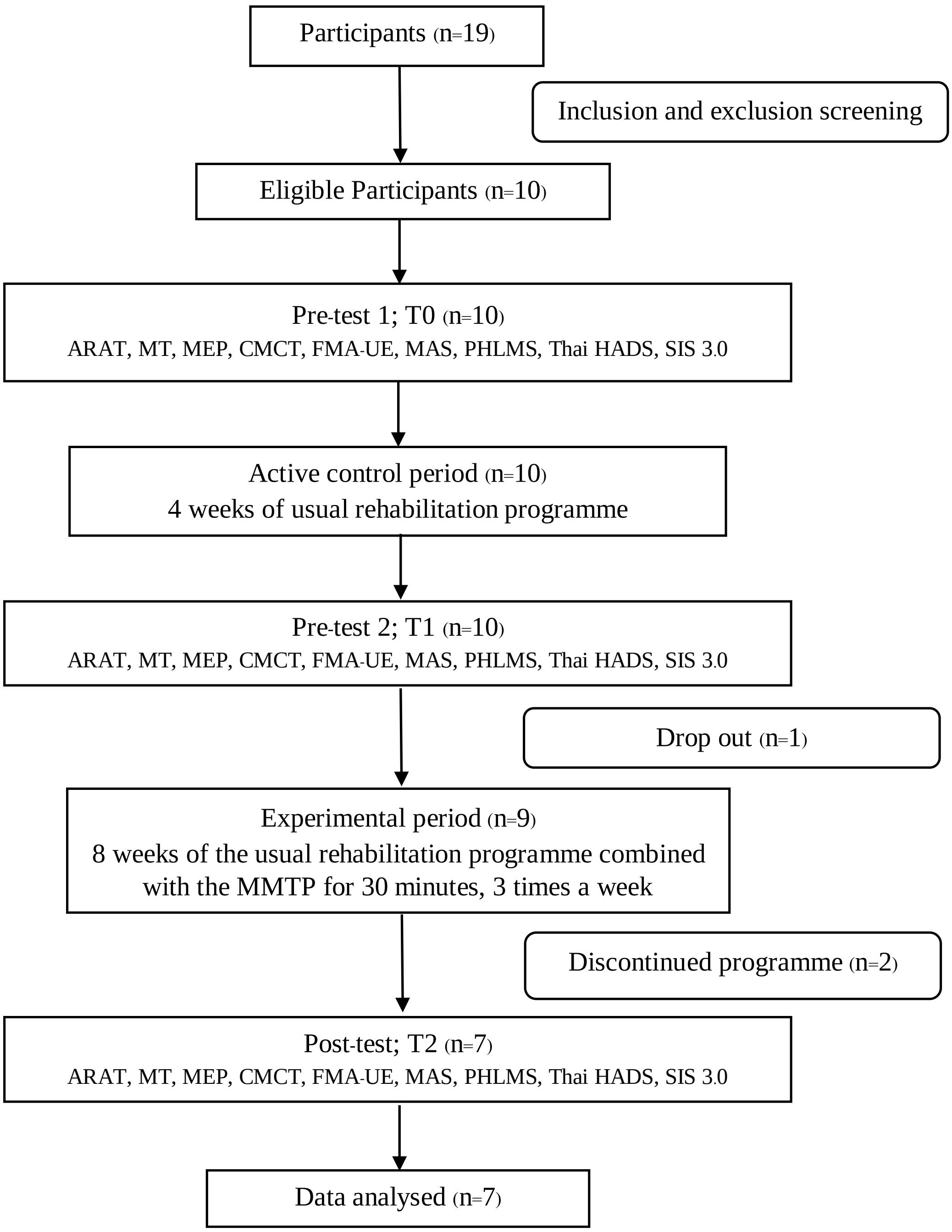

Figure 10. Flow diagram of the study procedure.

6.5.2 Recruitment

19 patients with stroke were screened for inclusion and exclusion criteria. In total, ten eligible cases were enrolled into this study. There was one drop out due to transportation problems, and two patients discontinued the study early because they moved to another city and could not arrange a time to practice. Thus, only seven cases completed the programme (Figure 10).

6.5.3 Participants characteristics

There were seven participants (1 female, 6 males). The mean age was 56.71±8.71 years (44 to 68 years). Four were right-handed, and three were left-handed. The average education level was 15.14±1.57 years: one patient held a diploma, one patient graduated from high school, and five patients completed undergraduate degree courses. The mean MMSE was 28.57±1.13 (range 27 to 30). Five patients had an ischemic stroke, and two had a hemorrhagic stroke; two patients had left hemispheric lesions, and five had right hemispheric lesions. The onset of stroke was 10 months to 9 years prior to study entry; two cases had a stroke within the last two years prior to study entry, three cases within the last 2 to 5 years, and two cases more than five years prior to study entry. Five patients had hypertension, two had hyperlipidemia, and one had diabetes mellitus as a predisposing disease. All patients had received a physiotherapy programme, and five patients had received an occupation therapy programme 1 to 3 times a week depending on the severity of disease. The degree of upper limb impairment was different in individual participants: Participant 1 could walk using an ankle-foot orthosis (AFO) for longer distances. He had moderate impairment and spasticity of the left upper limb and could not move his wrist. However, he could lift his hand to touch his mouth. Participant 2 could walk long distances and could ride a motorcycle. His left upper limb's range of movement was almost normal but he was lacking some maneuverability and durability. Participant 3 could walk long distances. He could move his left upper limb to a fair level but showed some reduction in the grip subscale. He could only partially move his wrist. Participant 4 needed moderate assistance to walk with a tripod cane and used an AFO for shorter distances. He had moderate to severe spasticity of his left upper limb and he could not move his upper left limb. Participant 5 walked short distances with minimal assistance from one person. He had a poor left hand function, especially in the pinch subscale. He could not move his left wrist. Participant 6 could walk long distances. He could raise his right upper limb to a fair level but showed some reduction in the pinch subscale. He could not move his right wrist. Participant 7 could walk long distances without any assistance. She could move her right upper limb, but had a reduced movement speed and also showed some impairment in the pinch subscale. Five of seven participants were experienced in meditation: four practiced sitting meditation and one practiced sitting meditation with walking meditation (Table 8).

Table 8. Demographic and clinical characteristics.

ID.	Gender	Age	Handedness	Education	MMSE	Type of stroke	Lesion side	Onset	FMA-UE	ARAT	Meditation experiences
1	Male	53	Right	Diploma	29	Ischemic	Right	7 years	38	1	No
2	Male	59	Right	Undergraduate	30	Ischemic	Right	14 months	66	57	Yes
3	Male	64	Left	High school	27	Ischemic	Right	10 months	51	43	Yes
4	Male	68	Left	Undergraduate	29	Hemorrhagic	Right	9 years	4	0	No
5	Male	61	Right	Undergraduate	29	Hemorrhagic	Right	3 years	36	8	Yes
6	Male	44	Left	Undergraduate	27	Ischemic	Left	4 years	38	20	Yes
7	Female	48	Right	Undergraduate	29	Ischemic	Left	3 years	57	49	Yes

6.5.4 Numbers analysed

Seven participants completed the 8 weeks of the usual rehabilitation programme combined with MMTP. All participants trained more than 80 per cent; the average percent of training was 93.45±5.82 (87.5 per cent to 100 per cent). Thus, all data from these participants were used for data analysis. Due to incomplete TMS data in two participants, TMS outcomes were used from five participants only.

6.5.5 Outcomes and estimation

6.5.5.1 Clinical outcomes

After four weeks of the usual rehabilitation programme (control period), we found a significant improvement in the results of the upper extremity domain of FMA-UE increasing from 24.29±10.52 (pre-test 1) to 25.14±10.17 (pre-test 2, p=0.034). The total score of the SIS 3.0 increased from 71.66±9.39 (pre-test 1) to 75.65±8.87 (pre-test 2, p=0.018). The effect size for the total score of SIS 3.0 was moderate (Cohen's *d*=0.42). The effect size for the participation domain of the SIS 3.0 was large (Cohen's *d*=0.89). The other outcome parameters did not change significantly during the 4-week of the usual rehabilitation programme.

After completing the 8-week period of the usual rehabilitation programme combined with MMTP (experimental period) there were significant improvements in the results of the MAS of the elbow flexor decreasing from 1.29±0.76 (pre-test 2) to 0.57±0.53 (post-test, p=0.025) with a large effect size (Cohen's *d*=1.1) and the finger flexor decreasing from 1.57±1.51 (pre-test 2) to 0.71±0.95 (post-test, p=0.034) with a moderate effect size (Cohen's *d*=0.68) (Figure 11), of the PHLMS increasing from 65.57±11.44 (pre-test 2) to 73.14±11.67 (post-test, p=0.027) with a moderate effect size (Cohen's *d*=0.66), of the perceived recovery domain of the SIS 3.0 increasing from 68.57±16.51 (pre-test 2) to 78.57±14.92 (post-test, p=0.045) with a moderate effect size (Cohen's *d*=0.64) and of the total score of the SIS 3.0 increasing from 75.65±8.87 (pre-test 2) to 80.25±9.78 (post-test, p=0.043) with a moderate effect size (Cohen's *d*=0.49). The other outcome parameters did not change significantly.

However, we found a large effect size for decreases in the depression domain of the Thai HADS (Cohen's *d*=1.02; p=0.058) and moderate effect sizes for increases in the emotion and participant domains of the SIS T3.0 (Cohen's *d*=0.69, p=0.116, and Cohen's *d*=0.62, p=0.207, respectively) (Table 9).

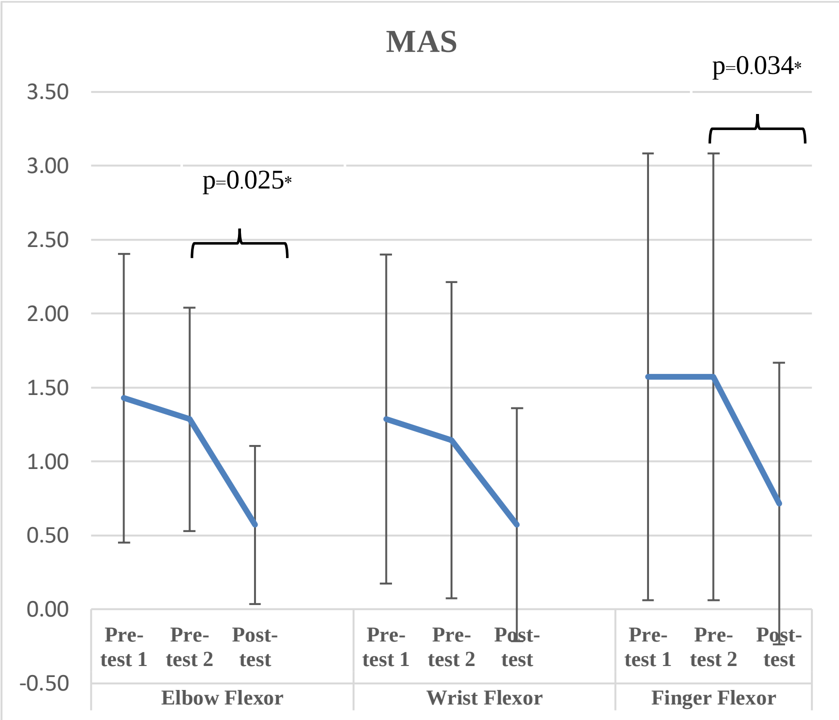

Figure 11. The MAS of the elbow, wrist, and finger flexors.

6.5.5.2 Motor cortical plasticity outcomes

With respect to brain plasticity outcomes as measured by TMS over motor cortex, 2 participants (ID.1 and 6) did not show any difference in the MT in the affected and the unaffected hemisphere over time and MEPs could not be elicited. One participant (ID.4) did not show a difference of the MT in the affected hemisphere over time but a decreased threshold in the unaffected hemisphere along with an elicited MEP (241.41µV) and a CMCT of 46.28 m/s at post-test. Two cases (ID.2 and 3), however, showed a considerable increase in their MEPs after eight weeks of rehabilitation programme plus MMTP in the affected hemispheres (+11.75% and +128.01%, respectively), while MEPs fluctuated over time in the unaffected hemispheres. In participant ID.2 the MT decreased in the affected hemisphere (-19.59%), and CMCT decreased in both, the affected and unaffected hemisphere, while there was an increase of the MT over time in the unaffected hemisphere. In participant ID.3, however, MT and CMCT did not change over time (Table 10).

Table 9. Changes in clinical outcomes over time (T0, T1, and T2).

No.	Variables	Pre-test 1 (T0)	Pre-test 2 (T1)	Post-test (T2)	p-value (T0&T1)	Effect size (T0&T1) Cohen's *d*	p-value (T1&T2)	Effect size (T1&T2) Cohen's *d*
1.	ARAT							
	Affected side	22.86 (23.88)	23.57 (24.09)	26 (24.93)	0.102	0.03	0.068	0.1
	Unaffected side	57	57	57	1.0	-	1.0	-
2.	FMA-UE							
	Upper extremity	24.29 (10.52)	25.14 (10.17)	26.43 (11.63)	0.034*	0.08	0.336	0.13
	Wrist	3.29 (4.5)	3.43 (4.72)	3.43 (4.72)	0.317	0.03	1.0	0
	Hand	9.57 (4.83)	9.57 (4.76)	10.71 (5.06)	1.0	0	0.063	0.24
	Coordinated/speed	3.71 (1.8)	3.71 (1.89)	4.43 (2.07)	1.0	0	0.059	0.38
	Total	40.86 (20.31)	41.86 (20.06)	45 (21.89)	0.102	0.05	0.078	0.16
3.	MAS							
	Elbow flexor	1.43 (0.98)	1.29 (0.76)	0.57 (0.53)	0.317	0.16	0.025*	1.1
	Wrist flexor	1.29 (1.11)	1.14 (1.07)	0.57 (0.79)	0.317	0.14	0.102	0.61
	Finger flexor	1.57 (1.51)	1.57 (1.51)	0.71 (0.95)	1	0	0.034*	0.68
4.	PHLMS							
	Awareness	34.29 (13.2)	35.43 (13.15)	40.29 (8.69)	0.102	0.09	0.176	0.37
	Acceptance	31.71 (14.36)	30.14 (13.25)	32.86 (12.48)	0.223	0.11	0.058	0.2
	Total	66 (12.78)	65.57 (11.44)	73.14 (11.67)	0.518	0.03	0.027*	0.66
5.	Thai HADS							
	Anxiety	5.57 (4.54)	5.29 (4.03)	5.29 (3.99)	0.593	0.06	1.0	0
	Depression	5.86 (2.73)	5.86 (2.79)	3.43 (1.9)	0.891	0	0.058	1.02
	Total	11.43 (6.9)	11.14 (6.12)	8.71 (5.28)	0.854	0.04	0.206	0.43
6.	SIS 3.0							
	Strength	47.14 (11.85)	52.86 (14.1)	55.71 (13.67)	0.102	0.48	0.194	0.2
	Memory	88.98 (8.64)	92.25 (5.88)	95.1 (6.33)	0.131	0.38	0.068	0.49
	Emotion	76.83 (15.76)	75.87 (14.25)	85.08 (12.42)	0.786	0.06	0.116	0.69
	Communication	97.55 (3.47)	98.78 (3.24)	99.59 (1.08)	0.18	0.35	0.655	0.25
	ADL	81.43 (15.95)	81.43 (12.04)	81.14 (13.66)	0.733	0	0.892	0.02
	Mobility	82.22 (15.4)	86.98 (12.6)	89.52 (11.09)	0.068	0.31	0.306	0.2
	Hand function	43.43 (31.62)	49.14 (31.05)	54.29 (30.97)	0.273	0.18	0.141	0.17
	Participation	67.35 (8.57)	74.93 (11.8)	83.21 (14.56)	0.068	0.89	0.207	0.62
	Perceived recovery	60 (20)	68.57 (16.51)	78.57 (14.92)	0.167	0.43	0.045*	0.64
	Total	71.66 (9.39)	75.65 (8.87)	80.25 (9.78)	0.018*	0.42	0.043*	0.49

* p-Value < 0.05, ARAT; Action Research Arm Test, FMA-UE; Fugl-Meyer assessment of the upper extremity, MAS; Modified Ashworth Scale, PHLMS; Philadelphia Mindfulness Scale, Thai HADS; Thai Hospital Anxiety and Depression Scale, SIS 3.0; Thai Version of the Stroke Impact Scale 3.0

Table 10. Changes in outcomes related to motor cortical plasticity over time (T0, T1, and T2).

Variables	MT (%)						MEP (μV)						CMCT (m/s)					
	AH			UH			AH			UH			AH			UH		
Participant	Pre1	Pre2	Post	Pre1	Pre2	Post	Pre1	Pre2	Post	Pre1	Pre2	Post	Pre1	Pre2	Post	Pre1	Pre2	Post
1	100	100	100	100	100	100	no MEP	no MEP	no MEP	no MEP	no MEP	no MEP	no CMCT	no CMCT	no CMCT	no CMCT	no CMCT	no CMCT
2	97	97	78	91	95	98	103.12	100.78	112.62	125	144.37	115.62	26.73	26.36	23.31	107.78	98.09	71.01
3	100	100	100	58	67	60	96.87	78.12	178.12	523.12	375	425.62	19.84	19.9	19.37	35.89	41.52	41.57
4	100	100	100	100	100	96	no MEP	no MEP	no MEP	no MEP	no MEP	241.41	no CMCT	no CMCT	no CMCT	no CMCT	no CMCT	46.28
6	100	100	100	100	100	100	no MEP	no MEP	no MEP	no MEP	no MEP	no MEP	no CMCT	no CMCT	no CMCT	no CMCT	no CMCT	no CMCT

Note MT; motor threshold (%), MEP; motor-evoked potential, CMCT; central motor conduction time, AH; affected hemisphere, UH; unaffected hemisphere, Pre1; pre-test1, Pre2; pre-test2, Post; post-test

6.6 Discussion

6.6.1 Feasibility of MMTP in patients with stroke

In the control period between pre-test 1 and 2, patients with stroke received only the usual rehabilitation programme for four weeks, which led to significant improvements in their upper extremity impairments and overall of quality of life. Moreover, there was a large effect size for improvements in the participation domain of quality of life and moderate effect size for improvements in the strength and perceived recovery domains. Although hand and arm function in the affected side were not statistically significantly changed, this change amounted to 3.11 percent. Existing evidence demonstrates that patients with chronic stroke can have restoration of hand and arm function along with neuroplasticity within four weeks of physiotherapy sessions at 50 minutes, five times a week (92). In contrast, the participants in this study underwent physiotherapy and occupational therapy in the range of only 1 to 3 days a week. Thus, the observed effect of receiving four weeks of their usual rehabilitation programme was not adequate to improve upper limb function in stroke patients.

In the experimental period between pre-test 2 and post-test, MMTP was added to the usual rehabilitation programme for eight weeks. Although the motor function of the upper limb in the affected side was not significantly improved, ARAT scores increased by 10.31 percent, three times the increase that was seen in the control period. In addition, spasticity was significantly reduced in the elbow flexor with a large effect size and in the finger flexors with a moderate effect size. Therefore, the findings suggest that MMTP has the potential to add to the usual rehabilitation programme for improving upper limb motor function in patients with stroke. Quality of life and mindfulness increased significantly with moderate effect sizes, and there was a large effect size associated with the decrease in depression. Therefore, this study confirmed that MMTP combined with the regular rehabilitation programme has feasible to improve both physiological and psychological issues in patients with stroke.

6.6.2 Arm and hand function and impairment

After 4 weeks of the usual rehabilitation programme the only significant change was found within the domain of the upper extremity of the FMA-UE. However, the absolute change was minimal with a score of 24.3±10.5 before and 25.1±10.2 after finishing the programme (p=0.034). Because significant differences may not always be clinically relevant (208) and p values alone do not inform on the magnitude and direction of an effect (208, 209), statistic significance alone is not enough to justify treatment decisions (208, 210). The treatment effect size, in contrast, is a quite good indicator for clinical relevance (208). It reveals the magnitude of the difference in treatment outcomes between the experimental and the control group (208, 211). The treatment effect size was small for all domains of the FMA-UE (Cohen's $d<0.2$), and the minimal detectable change (MDC) was 3.2 points only (212). Thus, 4 weeks of the usual rehabilitation programme did not show any clinically meaningful effect in patients with stroke.

After 8 weeks of the usual rehabilitation programme combined with MMTP, upper limb function and impairment outcomes as measured by ARAT and FMA-UE did not show any statistically significant difference either. However, due to a small sample size and/or a high variance, this does not automatically mean that this treatment was ineffective (208). ARAT scores increased by 10.3 percent. The FMA-UE increased by 11.9 percent and 19.4 percent in it's domains of hand and coordination/speed respectively, while the total FMA-UE score increased by 7.5 percent. 4 out of 7 participants had a MDC greater than 3.2 points with scores increasing from 34 to 39 (participant 1), from 54 to 59 (participant 3), from 41 to 45 (participant 6), and from 57 to 66 (participant 7). Because of a ceiling effect, no change could be detected in participiant 2. To further look for clinically meaningful changes, pooled baseline standard deviation scores were multiplied by 0.2 (208) resulting in a minimal clinically important differences (MCID) of approximately 4 (20.06 x 0.2). Thus, a mean difference higher than 4 might in fact indicate clinical effectiveness. A difference higher than 4 was found in 4 of 7 participants (again participants 1, 3, 6 and 7). In conclusion, 8 weeks of the usual rehabilitation programme combined with MMPT might in fact improve the hand and arm function of the affected upper limb. However, validation of these findings in a larger cohort are necessary.

This study is the first report of the effect of MMTP on arm and hand function in patients with stroke. Our systematic review in chapter 3 found that there were only three previous studies including one non-RCT (80) and two uncontrolled studies (37, 71) investigating the effect of mindfulness-based approaches on motor function in patients with stroke. Only one study showed a statistically significant increase in motor function, which was a non-controlled study by Moustgaard et al. in 2007. There was a significant improvement in the quality of life, in the domains of mobility (SS-QOL) and in physical components (SF-36). Especially the upper extremity domain of SS-QOL improved from 36.33±8.57 to 38.57±7.93 ($p=0.007$), which represents an increase by 6.17 percent, after completion of 9 weeks of MBCT. MBCT training took approximately 22 hours to produce this change. In contrast, the MMTP used in the present study had an average of 11.21 hours of training only. Moustgaard et al. explained that motor function improvement was due to a decrease in anxiety and depression, which in turn has contributed to stroke patients becoming more involved in physical activities. This is similar to our study, where patients with stroke had improvements in their depression symptoms with large effect size. It is therefore possible that, as a result of feeling less depressed, patients engaged more and concentrated on the rehabilitation programme, which contributed to their functional motor improvements.

Recovery of the motor function is a direct result of neuroplasticity (175) which can occur following a stroke (213) or mindfulness meditation practice (21, 23). The empirical evidence confirmed that meditation induces changes in the function and structure of the brain (21-23). It is well-known that neuroplasticity is induced by sensory input, repetitive motor activity, experience, and environment (136, 137, 180, 181). It was believed that the components of MMTP could promote neuronal re-organisation in stroke patients. Body scan may have stimulated recovery of somatosensory deficits and helped to provide good-quality sensory input to the sensory cortex for shaping M1, which directly affects motor function (86, 136, 137). Sitting meditation in the MMTP included both focused attention and open-monitoring which cultivates concentration, awareness, and attention (19, 140). Researchers demonstrated that meditation enhances attention performance and can help to reduce or ignore internal or external disturbances (19, 75, 141). Thus, it is possible that MMTP served to provide a conducive environment and appropriate experience for motor relearning and facilitated neuroplasticity in patients with stroke. Mindful-movement, however, is likely to be the key component of motor recovery. A meta-analysis study confirmed that intensive repetitive movement induces neuroplasticity resulting in the improvement of the impairment and functional recovery in stroke patients (87, 93). The present study suggests that mindful-movement in the MMTP, which was the repetitive passive or active exercising of the upper limb combined with specific PNF patterns, can induce plasticity of M1 (20, 52, 148).

However, MMTP provided in this study was insufficient for significant improvement in upper limb function. Although the results in Chapters 4 and 5 confirmed that MMTP could lead to statistically significant increases in the motor performance of the upper limb in healthy older adults, stroke patients may not have benefitted as strongly due to different perceptions of and cooperation with the MMTP training. Furthermore, they did not present with a healthy brain, but with mostly chronic brain damage from ischemic or hemorrhagic stroke. Therefore, it may be suggested that when stroke patients practice the MMTP for longer than eight weeks, it can lead to a statistically and clinically significant improvement of arm and hand function. In this study, stroke patients practiced the MMTP on average only 11.21 hours which is considered a short-term meditation (5 to 60 hours) (19). To achieve a clear result, patients with stroke should practice MMTP for long-term meditation (thousands of hours) (19) or a number of hours similar to a standardised MBI (23). According to a systematic review of Gotink et al. in 2016, the 8-week MBSR and MBCT could change the structure and function of the brain similar to traditional meditation. This training takes approximately 63 hours and results in brain plasticity in the prefrontal cortex, hippocampus, insula, and cingulate cortex, which relate to control of movement.

6.6.3 Spasticity

Since spasticity was not the main outcomes of this study, it was surprising that patients with stroke had a statistically and clinically significant decrease in spasticity with a moderate to large effect size compared with the control period. The relative change in spasticity during control and experimental periods were -9.79 percent and -55.81 percent, for the elbow flexor. Spasticity of the wrist flexor was reduced by -11.63 percent and -50.00 percent, respectively, while there was no change in spasticity during the control period but a -54.78 percent reduction during the experimental period for the finger flexor. Thus, this study can conclude that MMTP contributed to the reduction of spasticity in stroke patients. Spasticity is caused by the destruction of the pyramidal tract and parapyramidal fibres resulting in upper motor neuron syndrome. The interruption in the transmission of signals controlling normal tonic stretch reflexes leads to spasticity with exaggerated reflexes (214-216). Spasticity is found in approximately 39 percent of patients after one year of stroke and is more common in the upper limbs than the lower limbs (217). It is one of the impairments that exacerbates motor dysfunction and may cause other problems following a stroke (216, 217).

According to the systematic review in Chapter 3, no studies have been conducted to measure the effect of meditation on spasticity outcomes in stroke patients. The present study is, therefore, the first report on the effects of mindfulness meditation on spasticity in patients with stroke. The possible mechanisms of MMTP that may contribute to markedly reduced spasticity include the recovery of function of the affected upper extremity and learning to manage the factors that cause spasticity, which will be discussed below.

The repetitive movement of all joints in the upper limb combined with specific patterns of PNF, which is the essence of mindful movement, could maintain muscle and soft tissue length, as well as strengthen muscles of upper limbs in the affected side (218). The systematic review confirmed that repeated tasks of at least 20 hours per week could improve motor function and contribute to reducing spasticity (218). However, in the present study, the number of training sessions was limited, and only numerical improvement but no significant changes in upper limb impairment and function were found in addition to significantly reduced spasticity. It is possible that the effects of slow passive or active ranges of motion with awareness from mindful-movement training have limited effects on motor function but markedly reduce spasticity in the affected elbow and finger flexors (219). Moreover, PNF patterns of D1E and D2F are the reverse of typical spasticity positions, which may prevent abnormal spasticity (220). The body scan may be another mechanism that decreases spasticity. Many factors affect the occurrence of spasticity, such as excessive or inappropriate exertion, mental problems, pain, discomfort, constipation, infection, pressure ulcers, or tight clothing (216, 218). The body scan provides perception and awareness skills for the patient to detect the experiences that occur within their body (134). Thus, patients in the present study might have become better at detecting bodily changes and used this biofeedback to manage spasticity by reducing the aggravating factors (216).

These potential mechanisms could account for the significant decrease in spasticity when compared to the control period. Therefore, uses of MMTP in conjunction with the usual rehabilitation programme are strongly encouraged to better manage spasticity in stroke patients.

6.6.4 Other outcomes

Mindfulness, anxiety and depression, and quality of life were measured by PHLMS-TH, Thai HADS, and SIS 3.0. We found that after patients with stroke completed eight weeks of MMTP, the total score of PHLMS-TH, the perceived recovery domain of SIS 3.0, and the total score of SIS 3.0 showed statistically significant improvements. Although the depression domain of Thai HADS was just above the threshold for statistical significance, the effect size for the improvement was large.

Mindfulness did not change in the control period, but it was increased significantly with moderate effect size and a percent change of 11.54 percent after completing eight weeks of MMTP. Two studies (71, 80) reported in the systematic review in chapter 3 investigated the effects of MBCT and MBI in patients with stroke on mindfulness measured with different questionnaires (FFMQ and Chinese Version of MAAS). Merriman et al. (2015) reported that FFMQ was not statistically different after completing nine weeks of MBCT, but increased by 7.09 per cent. In contrast, Wang et al. (2018) showed that an intensive two weeks of MBI led to a significant difference in MAAS when compared with the usual care alone, which is a finding that is similar to this study.

In term of psychological outcomes, there was no significant difference over time, but the HADS depression domain had a large effect size for the 41.47 per cent decrease during the experimental period of while there was no change during the control period. There are several studies involving mindfulness programme to reduce anxiety and depression symptoms in patients with stroke. From my systematic review, there are six studies (35, 37, 56, 71, 78, 85) that assessed the effects of meditation in stroke patients on different anxiety and depression scales including BAI, BDI, BDI-II, STAI, and CPRS, but two studies (37, 71) used HADS. Five of these studies reported that mindfulness meditation programmes could improve mental states in patients with stroke. Moustgaard et al. (2007) reported that HADS had a significant improvement after completing nine weeks of MBCT. HADS anxiety decreased from 5.81±3.39 to 1.67±1.91 and HADS depression from 5.62±4.00 to 2.25±2.42. These pre-test scores are similar to the present study at 5.57±4.54 and 5.86±2.73 for anxiety and depression, respectively, whereas the post-test scores of our study were 5.29±3.99 and 3.43±1.9, respectively. This suggests that MBCT has better effects on anxiety and depression than MMTP. This is probably due to the effects of cognitive behavioural therapy, which is one of the main components of MBCT, and may have a direct impact on the change (34, 37). In contrast, Merriman et al. (2015) showed that HADS did not significantly improve after practising nine weeks of MBCT, but numerically the average score of anxiety and depression decreased from 8.75±4.27 to 6±1.83 and from 7.5±2.08 to 6.25±3.86, respectively. This study had a limited sample size of only four stroke patients, and can thus not be directly compared to Moustgaard et al.'s study.

It is hypothesised that MMTP had some beneficial effects on depression state in the present study as a result of improved mindfulness and the effect of relaxation. Mindfulness cultivates awareness of being in the present moment without judgment, resulting in being compassionate, wise and awake (35, 80). It can be helpful in reducing rumination and accepting the changes or losses that have occurred with self-compassion (37, 80). In addition, mindfulness programme causes relaxation by stimulating the parasympathetic nervous system (56).

Although the usual rehabilitation programme alone improved the quality of life significantly, when MMTP was added to the experimental period, the quality of life was further improved. The percent change during the control and experimental periods were 5.57 per cent and 6.08 per cent, respectively. Moreover, in the experimental period, the perceived recovery domain also showed significant improvement with moderate effects size, and there also were moderate effect sizes for improvements in the domains of memory, emotion, and participants. Two studies (37, 71) investigated the effect of MBCT on different quality of life questionnaires (SS-QoL and WHOQoL-BREF). Moustgaard et al. (2007) demonstrated that nine weeks of MBCT could increase SS-QoL scores statistically significantly. In contrast, Merriman et al. (2015) found that WHOQoL-BREF did not change after nine weeks of MBCT, probably due to the sample size limitations (4 cases). The evidence reported that anxiety and depression have a significant effect on quality of life (37, 56). Thus, when the patient has more mindfulness and awareness in the present, an understanding and acceptance of all experiences ensues, resulting in reduced anxiety and depression. They then have more motivation to cooperate with the rehabilitation programme. As a final outcome, the patient then experiences a better quality of life.

6.6.5 Motor cortical plasticity

Unfortunately, there were some problems with using TMS in stroke patients including the time spent finding the hotspot because some patients could not sit for a long time before they fatigued and because some were anxious about the magnetic waves. Thus, we obtained TMS data for analysis from only 5 cases. As a result, the data may not be sufficient to summarise the effects of MMTP on brain plasticity in patients with stroke. However, the experience gained regarding how to handle TMS in patients with stroke will be of use for further studies in the future.

TMS over motor cortex provided the outcomes of MT, MEP, and CMCT. MT is often elevated in stroke patients due to decreased cortical excitability and adverse effects on the corticospinal tract (151, 157, 166). A very high MT is linked to poor prognosis due to loss of axons or neurons resulting in poor motor recovery (150, 221). The evidence reported is that MT in the affected hemisphere was higher than in the unaffected hemisphere (158) . We found that 4 out of 5 patients had their highest MT at 100 percent and MT in affected hemisphere higher than in the unaffected hemisphere. Thus, it was seen that participants in this study probably had a poor prognosis from a severe and chronic stroke.

The MEP amplitude represents the integrity of the nervous system in the control of movement, from the excitability of motor cortex, corticospinal tract, nerve roots, and nerve impulses to the peripheral motor pathway to the target muscle (149). No elicited MEP or MEP with low amplitude indicates damage of the nerves or axons in the motor pathway (150). It is usually seen in patients with severe weakness (151). Existing evidence shows that motor recovery in patients with stroke is associated with a recurrence of MEPs and increases in the amplitude of MEPs during the recovery period (88, 151, 159, 161). It is interesting that in patients with no recovery of the affected side, MEPs in the unaffected side can increase and lead to hemispheric asymmetry (151). In patients with chronic stroke, the MEP of the affected hemisphere is significantly smaller than that of the unaffected hemisphere (151, 158). This suggests that if the patient has better recovery, hemispheric asymmetry in MEPs should be gradually reduced (222).

Three participants (ID.1, 4, and 6) had very high of MT at 100 percent, and no reappearance of MEP and CMCT over time in the affected hemisphere. This is because three patients had a chronic stroke with 7, 9 and four years of stroke onset, resulting in atrophy of the FDI muscles, and a FMA of wrist score of zero. In two patients (ID.2 and 3) who had a stroke 14 months and ten months previously, MEPs were elicited and changed over time. Patient ID.3 had a very high MT in the affected hemisphere at 100 per cent over time, and other outcomes fluctuated. Only the MEPs in the affected hemisphere increased markedly from 78.12 (pre-test 2) to 178.12 (post-test). Patient ID.3's ARAT scores on the affected side also increased from 37 (pre-test 2) to 41 (post-test), showing some evidence for improvement of motor function. However, MT and CMCT did not change. This may be due to the mindfulness score of the patient not increasing, anxiety and depression worsening (HADS score increased from 10 to 14), and the overall quality of life was remaining unchanged.

In contrast patient, ID. 2 had good brain plasticity outcomes along with better clinical outcomes. MT in the affected hemisphere decreased from 97 to 78, which approaches the MT in older adults reported in chapter 5 (approximately 80 to 82). MEPs in the affected hemisphere increased from 100.78 to 112.62 but remained smalled than the MEPs found in older adults (around 220 to 280). MT and MEP also became more symmetrical across hemispheres. As a result, ARAT and FMA-UE scores were at the ceiling. Mindfulness scores increased from 63 to 88, while HADS decreased from 6 to 2, resulting in an overall quality of life increase from 82.95 percent to 91.33 percent. Therefore, the present study was able to demonstrate clear and consistent improvements in motor cortical plasticity alongside the associated physiological and psychological outcomes in one patient who received MMTP with their normal rehabilitation programme.

6.7 Limitations

As this study was a preliminary study to examine the feasibility of MMTP in stroke patients, there were some limitations. A control period was used, but there was no comparison group to rule out the effects of other contributing variables that are not related to MMTP on the findings. Thus, it is necessary to use randomised controlled clinical trials for investigating the effects of MMTP in stroke patients and to increase the sample size sufficiently for statistical analysis. Participants in this study showed a large amount of heterogeneity, such as the type of stroke, lesion side, severity, or time since stroke. Therefore, the next study should select participants with more similar clinical characteristics. Moreover, the outcomes measure used in this study were largely able to show the effectiveness of MMTP, but much less able to explain the underlying mechanisms for this effectiveness. Future studies should also measure changes in somatosensory deficits to confirm the effectiveness of body scan component in the MMTP which is essential for shaping M1 of arm and hand function, by FMA in the domain of sensory assessment. In addition to a single pulse, paired-pulse TMS could be used to obtain ICI and ICF, which reflect the cortical reorganisation by excitatory neural circuits within the motor cortex (165), and fMRI could be used to measure plastic changes in motor system activity and cortical territory (102, 223).

6.8 Conclusion

This preliminary study confirmed that it is feasibility to use MMTP in patients with stroke. The integration of MMTP into the usual rehabilitation programme could decrease spasticity and upper limb impairment, and tended to improve arm and hand function on the affected side. It also improved mindfulness, caused reduced symptoms of depression, and finally improved the overall quality of life. In one patient, this study was able to demonstrate clear changes in motor cortical plasticity as a result of MMTP, which were consistent with changes in their physiological and psychological outcomes. However, we need further, better controlled studies with larger sample sizes to confirm the effectiveness of MMTP as a new intervention programme for improving motor function in patients with stroke.

CHAPTER SEVEN

A SUMMARY OF THE MAIN FINDINGS, IMPLICATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

7.1 Chapter overview

This chapter presents a summary of the main findings, implications and future research suggestions for each chapter or study including 1) meditation for motor function in patients with stroke: a systematic review, 2) the effect of a mindfulness movement therapy programme on the motor performance of the upper limbs in older adults: a preliminary study, 3) the effect of a mindfulness movement therapy programme on the motor performance of the upper limbs and motor cortical plasticity in healthy older adults: a randomized single-blind controlled trial, and 4) the effect of a mindfulness movement therapy programme on arm and hand function in patients with stroke: a preliminary study. The overall conclusion from this thesis is presented at the end.

7.2 Meditation for motor function in patients with stroke: a systematic review

The primary aim of this systematic review was to investigate the effect of meditation on motor function in patients with stroke. The second aim was to explore the potential benefits of meditation in patients with stroke. There were 13 included studies (2007 to 2018) met the inclusion and exclusion criteria including 1 RCT, three non-RCT, six non-controlled studies, and 3 case report. The meditation programmes were found comprising of 4 studies of MBCT, three studies of MBSR, four studies of MM, one study of MM combined with AMMP, and one study of Brahama Viharas. The primary aim of each study focused on anxiety and depression of 4 studies, mental fatigue of 4 studies, aphasia of 3 studies, the comfort of 1 study, and group setting with general benefits of 1 study. Risk of bias in individual studies as measured by the revised Cochrane risk of bias tool was high due to the score ranging only between 1 and 4 from 10 (mean=2.38±1.04). A meta-analysis was not possible due to heterogeneity and limitation of comparable studies.

7.2.1 Summary of main findings

The effect of meditation on motor function in patients with stroke

There were only three studies (one non-RCT and two non-controlled studies) investigating the effect of meditation on measure outcomes involving in motor function in patients with stroke. The total participants in the 3 studies who completed the mindfulness programme were 52 cases; 25 patients from Wang et al. (2018) investigated the effects of MBI combined with usual care compared with the usual care on BBS, 10MWT, and FAC; 23 patients from the study of Moustgaard et al. (2007) examined the effects of MBCT on SF-36 and SS-QOL; and 4 cases from the study of Merriman et al. (2015) assessed the effect of MBCT on WHOQol-BREF. The risk of bias in the three studies was 4, 2, and 2, and the quality of the studies was 5, 1, and 1, respectively. We found that only Moustgaard et al. (2007) showed statistically significant improvement after completing nine weeks and three months follow up of MBCT in the physical domain of SF-36, and the mobility and upper extremity domains of SS-Qol. According to the study of Wang et al. (2018) although BBS, 10MWT, and FAC were not significant between groups but significantly improved within both experimental and active control group. However, more high-quality studies are needed to confirm the effect of meditation on the motor function in patients with stroke.

The potential benefits of meditation in patients with stroke

It was found that meditation has potential benefits on psychological, psychosocial, physiological, and neuropsychological outcomes. There were a variety of measure outcomes to investigate the effects on meditation consisting of ten studies measuring 6 psychological outcomes including anxiety, depression, mental fatigue, affect, self-compassion, and mindfulness, three studies evaluated 5 psychosocial outcomes including perceived tress, sleep disturbance, health status, quality of life, and expectancy, four studies assessed 3 physiological outcomes including ANS, ambulation ability, and comfort, and nine studies investigated 5 neuropsychological outcomes including attention, divided attention, language, information processing speed, and working memory.

The highest quality and the lowest risk of bias in the included studies (moderate, at approximately 3 to 5) was found in 4 studies including 1 RCT and three non-RCT. Two studies (1 RCT and 1 non-RCT) from Johansson et al. investigated the effects of MBSR in TBI and stroke compared with waitlist control in 2012 and compared with walking in 2015. The results demonstrated that MBSR could significantly improve mental fatigue, anxiety, depression, attention, word fluency, and information processing speed. Marshall et al. (2018) evaluated the effects of 5 days MM combined with AMMP compared with mind wandering on attention, language, and ANS. The resulted showed that there were no significant differences in all outcomes except word fluency, which improved immediately after MM training. Wang et al. (2018) investigated the effects of 2 weeks MBI combined with the usual care and compared with the usual care on comfort, ambulation ability, and mindfulness. They found that only mindfulness and some domains of comfort showed statistically significant improvements between the groups. Therefore, it was concluded with limited information that meditation could reduce anxiety, depression, mental fatigue, and improve mindfulness, word fluency, and comfort.

7.2.2 Implications of the research

Meditation programmes, whether MM, MBI, MBSR, or MBCT, could be combined with a standard treatment for a superior effect in term of psychological, psychosocial, physiological, and neuropsychological outcomes. Meditation in each programme could be considered for patients depending on problems, physical examination of an individual patient, and the expertise and clinical decision-making of the therapist. Moreover, no harm was reported from any mindfulness meditation programme. In addition, meditation is inexpensive, require little resources, and is flexible to practise.

7.2.3 Future research suggestions

A new review should be done in 5 years when more research hopefully of better quality could be included such as studies in English and quantitative studies to get broader information.

7.3 The effect of a mindfulness movement therapy programme on the motor performance of the upper limbs in older adults: a preliminary study

The aim of this study was to propose and test the feasibility of MMTP and to investigate its effects on motor performance of the upper limbs in a sample of UK older adults. The design of the study was a mixed design of randomised and non-randomised preference. Twenty-five older participants (50-71 years) were assigned into three groups 1) MMTP group (n=9), 2) active control (AC) group (n=8), and 3) control group (n=8). There was no significant difference in baseline data in 3 groups. The MMTP group received a body scan technique, sitting meditation, and mindful-movement. AC group listened to an arm anatomy audiobook and went through sitting meditation. Control group did not get any programme. MMTP and AC groups practised three times a week for 30 minutes over an 8-week period with guided CD at home. The primary outcome was the JHFT measured in all groups. The secondary outcomes were the cortical motor and attentional function as measured by EEG, mindfulness, mood, perceived stress, and quality of life as measured by the FMI, the POMS-SF, the PSS-10, and the CASP-19 measured in MMTP and AC groups. All outcomes were measured at baseline and after eight weeks.

7.3.1 Summary of main findings

The results showed that only MMTP and AC demonstrated significant JHFT improvements, for both dominant and non-dominant hands in the MMTP group with large effect size, and for the non-dominant hand in the AC group with large effect size. In the MMTP group, there were significant improvements in the vigour/activity domain with moderate effect size as well as in the total score of the POMS-SF with moderate effect size. Sensorimotor cortical engagement during movement imagination was measured by oscillatory activity in the mu alpha range and improved significantly only in the MMTP group from before the intervention to after. Moreover, mu alpha activity correlated with post-intervention JHFT performance only in MMTP group for the non-dominant limb. Selective attention to the upper limbs was measured overtly as performance in a tactile oddball task and covertly with the P300 component of the somatosensory event-related potentials. Selective attention increased from before the intervention to after for the MMTP group, but for not the AC group, especially for the non-dominant limb.

7.3.2 Implications of the research

These results suggest that MMTP facilitates the control of the overt motor and attentional performance of the upper limbs in older adults by improving sensorimotor and attentional functioning in the brain. These findings encourage further investigations with improved methodology and larger sample sizes to confirm the effects of MMTP as a new intervention to improve motor performance in patients with movement disorders, such as those following stroke.

7.3.3 Future research suggestions

The study design should be a RCT with a blind assessor and increased sample size. In addition, the culture and environment of the population used in the next study should differ to show the effectiveness of MMTP on a different population in a different context.

7.4 The effect of a mindfulness movement therapy programme on the motor performance of the upper limbs and motor cortical plasticity in healthy older adults: a randomised single-blind controlled trial

The study aimed to investigate the feasibility and the effects of MMTP on motor performance of the upper limbs in a sample of the healthy Asian older population. A randomised single-blind controlled trial was used in this study. Thirty-six healthy older participants (55-65 years) were assigned into two groups 1) MMTP group (n=16) received a body scan technique, sitting meditation, and mindful-movement and 2) active control group (n=19) received listened to music, relaxation technique, and swinging arms exercise. Both groups practiced 30 minutes, three times a week on non-consecutive days, for eight weeks with guided CD at home. The primary outcome was the JHFT and cortical motor plasticity as measured by TMS including MT, MEP, and

CMCT. The secondary outcomes were mindfulness, anxiety and depression, perceived stress, and quality of life as measured by the PHLMS-TH, the Thai HADS, the TGDS, the T-PSS-10, and the WHOQOL-BREF-THAI measured in MMTP and AC groups. All outcomes were measured at baseline and after eight weeks.

7.4.1 Summary of main findings

Although there was no significant difference between the two groups in all outcomes, the CMCT in the MMTP group increased more than in the AC group at post-test with moderate effect size. Moreover, in the MMTP group, the CMCT increased statistically significant in the right hemisphere from pre to post-test, while there were no significant differences in the AC group. The motor performance was statistically significantly improved in both groups, but improvement in the trained (non-dominant) hand of the MMTP group had a large effect size, while that in the dominant hand in the MMTP group and both hands in the AC group had moderate effect sizes. In addition, in the AC group, there was a significant improvement of T-PSS-10 from pre to post-test.

7.4.2 Implications of the research

The results suggest that MMTP has the feasibility to improve motor performance in healthy older adults. It tended to increase nerve conduction velocity from the right hemisphere to the left upper limb resulting in statistically significant improvement of motor performance speed in the trained hand with large effect size. Therefore, MMTP was applied in the patients with stroke to investigate the feasibility of its use and the effects on arm and hand function.

7.4.3 Future research suggestions

Cortical motor plasticity could additionally be measured as intracortical excitability via paired-pulse TMS including ICI and ICF, or as cortical motor territory changes using fMRI.

7.5 The effect of a mindfulness movement therapy programme on arm and hand function in patients with stroke: a preliminary study

The aims of this preliminary study were to investigate the feasibility and the effects of MMTP on arm and hand function, and on cortical motor plasticity in patients with stroke. Seven patients with stroke (44-68 years) received their usual rehabilitation programme for four weeks (control period), and after that, they received the usual rehabilitation programme combined with MMTP for eight weeks (experimental period). The researcher provided the MMTP face to face. The primary outcome was arm and hand function as measured by the ARAT. The secondary outcomes were cortical motor plasticity, upper limb impairment, spasticity, mindfulness, anxiety and depression, and quality of life as measured by the TMS including MT, MEP, and CMCT, FMA-UE, the MAS, PHLMS-TH, the Thai HADS, and the SIS 3.0. All outcomes were measured by an independent physiotherapist in order to eliminate bias from the research three times at baseline (pre-test 1), after four weeks of the usual rehabilitation programme (pre-test 2) and after eight weeks of the usual rehabilitation programme combined with MMTP (post-test).

7.5.1 Summary of main findings

The results demonstrated that the four weeks of the usual rehabilitation programme caused statistically significant improvements in the upper extremity domain of FMA-UE and the total score of quality of life. Although in the experimental period, arm and hand function did not significantly improve, it did show promising numerical increases. Moreover, there was a statistically significant improvement in spasticity, mindfulness, and quality of life after completing eight weeks of MMTP. Unfortunately, the TMS outcomes were incomplete and quite varied depending on the condition of the individual patients. However, patient ID. 2 clearly and consistently demonstrated the improvement of motor cortical plasticity along with better clinical physiological and psychological outcomes after completing eight weeks of MMTP with their usual rehabilitation programme.

7.5.2 Implications of the research

It appears that there is potential to add MMTP into standard rehabilitation programmes to get a superior effect not only on arm and hand function but also spasticity, mindfulness, and quality of life. However, high quality further studies are needed to confirm the effects of MMTP and its underlying impact on motor cortical mechanisms as a new intervention programme for improving motor function in patients with stroke.

7.5.3 Future research suggestions

A RCT with a larger sample size should be used in further studies in order to have a comparison group to confirm the effects of MMTP and to eliminate confounding factors. In addition, pair-pulsed TMS or fMRI could be used to get more evidence of neuroplasticity. This study included patients with varying characteristics, such as severity of the lesion, stage of stroke, type of stroke so, a future study should be undertaken with a similar stroke group. In addition, it should include study of the long-term effect of MMTP and in patients with acute stroke to find the optimal stage that the inclusion of MMTP may be effective.

7.6 Conclusion of this thesis

Based on the results of all three studies, it can be concluded that MMTP has the potential for integration into usual rehabilitation programmes to get a more superior effect than the usual rehabilitation programme alone. It has been found that MMTP can improve not only the motor performance of the upper limb accompanied by better motor cortical plasticity, but can also improve depression, mood, mindfulness, and quality of life. Since MMTP is designed to be a combination of three components or approaches to provide the best possible treatment, it is not possible to empirically determine which element is the most important in bringing about these improvements. Therefore, based on the results of our studies, the hypothesised mechanism of MMTP for improving arm and hand function in patients with stroke is shown in Figure 12.

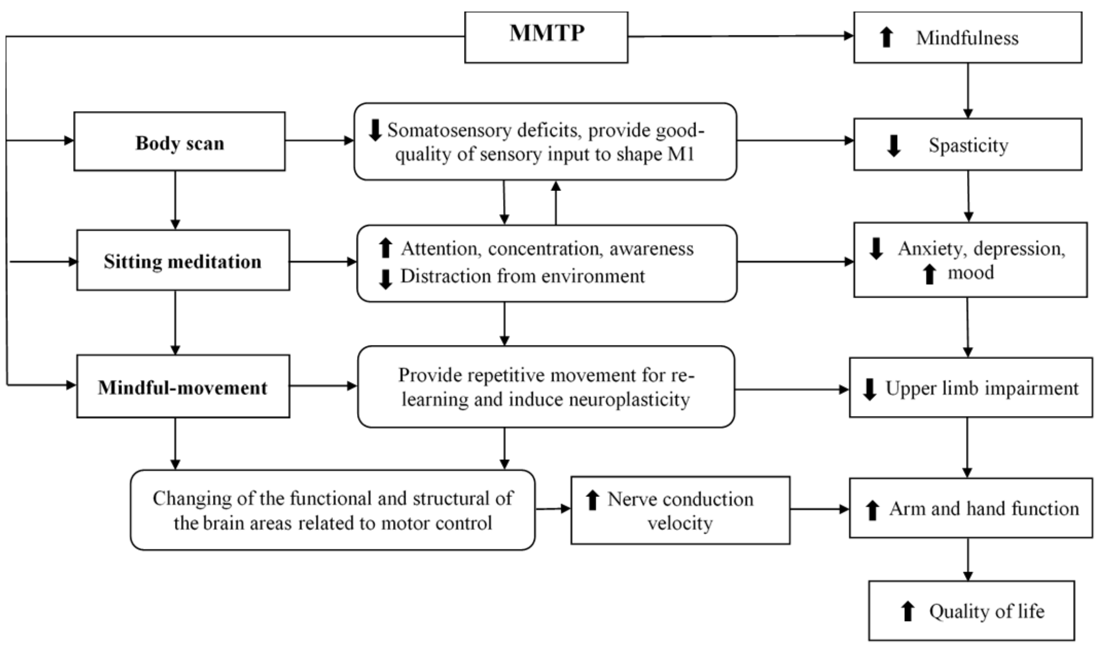

Figure 12. The proposed mechanism of MMTP on arm and hand function and other outcomes in patients with stroke.

7.7 Overall thesis

There are several problems that may develop following a stroke including both non-physical and physical impairments such as alterations to attention, cognition, perception, mood, anxiety, depression, mental fatigue, somatosensory deficits, and motor dysfunction. MCA is the most common pathological site affecting 87 per cent of all stroke patients. It supplies the lateral surface of a cerebral cortex resulting in severe impairment of arm and hand function rather than leg and foot function. Therefore, in the clinical setting, stroke patients can walk first, but retain longer-term impairment of the upper limbs due to a slower recovery. Full recovery of upper extremity function occurs in only 20 per cent of cases. Consequently, patients with stroke tend to have poor hand function for performing activities of daily living such as self-care, homemaking, and leisure. As a result, learned non-use of the affected upper limb further hinders recovery and is associated with the development of secondary complications such as inferior shoulder subluxation, shoulder pain, and shoulder-hand syndrome. After that, anxiety and depression increases, and finally, stroke patients' quality of life worsens. While upper limb intervention approaches are still controversial, it is recommended that mindfulness meditation programmes are integrated into standard physiotherapy programmes for their well-established benefits to both mental and physical well-being. At present there is a lack of evidence related to motor function. Furthermore, existing evidence demonstrates that short term and long term meditation induce neuronal plasticity and cause both structural and functional changes in brain areas related to motor control, for instance, prefrontal cortex for motor planning, anterior and mid-cingulate cortex for self-control and behavioral modification, insula for self-awareness of posture and movement, hippocampus for learning of movement, and cerebellum for comparing and controlling movement.

However, there exist no specific mindfulness meditation programmes designed to improve motor function. Therefore, this thesis developed and proposed a new protocol of mindfulness movement therapy programme for improving arm and hand function in patients with stroke. MMTP is designed for people who have had motor deficits, such as stroke patients. It is based on MBSR and MBCT, consisting of body scan, sitting meditation, and in particular of mindful- movement combined with physiotherapy techniques. There were four phases for developing and investigating the feasibility and the effects of MMTP on motor performance. In the first phase, we conducted a systematic review to explore the potential benefits of meditation, especially on motor function in patients with stroke. Four previous studies with the highest quality showed that mindfulness meditation programmes could decrease anxiety, depression, mental fatigue, and improve word fluency and quality of life in patients with stroke. There was insufficient data to summarise the effects of meditation on motor function and other outcomes due to the heterogeneity of the included studies and a high risk of bias with a poor quality of studies. Moreover, we found that no mindfulness programme had been presented in the literature for improving motor function in patients with stroke. Thus, the MMTP proposed in this thesis is the first mindfulness programme for the management of motor deficits in patients with stroke. In the second phase, the feasibility of MMTP was investigated, and its effects on motor performance of the upper extremities were measured in the UK older population. There were three groups including MMTP, active control, and control group. The results showed that MMTP was feasible to use in older adults to improve motor performance of the upper limbs accompanied by better cortical motor activities, attentional performance, and mood. After that, in the third phase, the study design was improved in methodology and in increased sample size. Moreover, we used TMS to measure cortical motor plasticity including MT, MEP, and CMCT in an Asian older population. The results demonstrated that MMTP could increase nerve conduction velocity from M1 to the muscles in the upper limb, causing enhanced motor performance speed of the upper extremities. In the last phase, MMTP was evaluated for feasibility of its use and its effects on arm and hand function in patients with stroke. MMTP was delivered to patients in an individual-based format and face to face. It was found that MMTP was possible to apply in stroke patients. It has the potential to reduce impairment and improve motor function. Moreover, spasticity, mindfulness, and quality of life improved after completing eight weeks of MMTP combined with the usual rehabilitation programme. Alongside these changes, there was also some preliminary evidence for MMTP-related neural plasticity in motor cortex.

In conclusion, the thesis provides promising evidence that MMPT might improve arm and hand function as well as stimulate neuroplasticity, reduce spasticity and enhance mindfulness as well as quality of life in stroke patients that should be followed up with larger scaled RCTs. MMTP has the potential to integrate with the usual rehabilitation programme for the management of upper limb problems in stroke patients. In addition, MMTP is a relatively flexible and inexpensive training programme, there is no need for special equipment, and no harm was reported on its use within this thesis.

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APPENDIX

Appendix I. The International Prospective Register of Systematic Reviews (PROSPERO) registration number.

PROSPERO
International prospective register of systematic reviews

NHS
National Institute for Health Research

Meditation for motor function in patients with stroke: a systematic review

Weeranan Yaemrattanakul, Joanna Jackson, Helge Gillmeister

Citation

Weeranan Yaemrattanakul, Joanna Jackson, Helge Gillmeister. Meditation for motor function in patients with stroke: a systematic review. PROSPERO 2018 CRD42018098989 Available from: http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018098989

Review question

Does meditation improve motor function in patients with stroke?

Searches

Literature search strategies will be developed using medical subject headings (MsSH) and text words related to meditation in patients with stroke. A literature search will be undertaken using 1) health sciences databases; MEDLINE, Cochrane Library, CINAHL, PsycINFO, EMBASE 2) databases outside health sciences especially multidisciplinary; Scopus, Web of Science, ProQuest, and ScienceDirect 3) unpublished studies databases; ClinicalTrials.gov, WHO ICTRP, Conference websites, ProQuest Dissertation and Theses Global, BASE, British Library and Google Scholar. Electronic databases are searched to locate studies from the first available year to June 2018.

The databases are searched for English language studies using the following terms: "stroke" or "post-stroke" or "cerebrovascular disease" or "CVA" or "hemiplegia" or "hemiparesis", in combination with "meditation" or "mindfulness" or "mindfulness meditation" or "Vipassana meditation" or "Zen meditation" or "mindfulness-based intervention" or "MBI" or "mindfulness-based stress reduction" or "MBSR" or "mindfulness-based cognitive therapy" or "MBCT".

Additionally, reference lists of selected articles and other reviews are checked for additional eligible studies.

Types of study to be included

We will include all full-text quantitative study but exclude systematic review and meta-analysis.

Condition or domain being studied

Patients with any acute or chronic stroke. Motor function.

Participants/population

Inclusion criteria: Patients with any acute or chronic stroke.
Exclusion criteria: Patients with stroke under 18 years of age.

Intervention(s), exposure(s)

The intervention focuses on formal meditation or interventions describing formal meditation as part of their curricula such as MBSR or MBCT, but without substantial exercise components to avoid exercise as a confound. Therefore, studies involving mind-body interventions, such as yoga and tai chi, are not considered eligible, even though yoga, for example, clearly involves meditation.

Comparator(s)/control

Given the broad perspective for the intervention of interest, all comparisons will be included.

Appendix II. Ethical Approval by the University of Essex, Faculty of Science and Health Ethics Committee.

University of Essex

Application for Ethical Approval of Research Involving Human Participants

This application form must be completed for any research involving human participants conducted in or by the University. 'Human participants' are defined as including living human beings, human beings who have recently died (cadavers, human remains and body parts), embryos and foetuses, human tissue and bodily fluids, and human data and records (such as, but not restricted to medical, genetic, financial, personnel, criminal or administrative records and test results including scholastic achievements). Research must not commence until written approval has been received (from departmental Director of Research/Ethics Officer, Faculty Ethics Sub-Committee (ESC) or the University's Ethics Committee). This should be borne in mind when setting a start date for the project. Ethical approval cannot be granted retrospectively and failure to obtain ethical approval prior to data collection will mean that these data cannot be used.

Applications must be made on this form, and submitted electronically, to your departmental Director of Research/Ethics Officer. A signed copy of the form should also be submitted. Applications will be assessed by the Director of Research/Ethics Officer in the first instance, and may then passed to the ESC, and then to the University's Ethics Committee. A copy of your research proposal and any necessary supporting documentation (e.g. consent form, recruiting materials, etc) should also be attached to this form.

A full copy of the signed application will be retained by the department/school for 6 years following completion of the project. The signed application form cover sheet (two pages) will be sent to the Research Governance and Planning Manager in the REO as Secretary of the University's Ethics Committee.

1. Title of project: The effect of a Mindfulness Movement Therapy Programme on arm and hand function in healthy adults and in patients with stroke

2. The title of your project will be published in the minutes of the University Ethics Committee. If you object, then a reference number will be used in place of the title.
   Do you object to the title of your project being published? Yes ☐ / No ☒

3. This Project is: ☒ Staff Research Project ☐ Student Project

4. Principal Investigator(s) (students should also include the name of their supervisor):

Name:	Department:
Dr Helge Gillmeister	Psychology
Mr Weeranan Yaemrattanakul Prof Joanna Jackson	School of Health and Human Sciences School of Health and Human Sciences

5. **Proposed start date:** 10/12/2016
6. **Probable duration:** 2 years

7. Will this project be externally funded? Yes ☐ / No ☒
   If Yes,

8. What is the source of the funding?

9. If external approval for this research has been given, then only this cover sheet needs to be submitted

External ethics approval obtained (attach evidence of approval) Yes ☐ / No ☒

Declaration of Principal Investigator:

The information contained in this application, including any accompanying information, is, to the best of my knowledge, complete and correct. I/we have read the University's *Guidelines for Ethical Approval of Research Involving Human Participants* and accept responsibility for the conduct of the procedures set out in this application in accordance with the guidelines, the University's *Statement on Safeguarding Good Scientific Practice* and any other conditions laid down by the University's Ethics Committee. I/we have attempted to identify all risks related to the research that may arise in conducting this research and acknowledge my/our obligations and the rights of the participants.

Signature(s):

Name(s) in block capitals: ....Helge Gillmeister..

Date: 1/9/2016

Supervisor's recommendation (Student Projects only):

I have read and approved the quality of both the research proposal and this application.

Supervisor's signature:...

Outcome:

The Departmental Director of Research (DoR) / Ethics Officer (EO) has reviewed this project and considers the methodological/technical aspects of the proposal to be appropriate to the tasks proposed. The DoR / EO considers that the investigator(s) has/have the necessary qualifications, experience and facilities to conduct the research set out in this application, and to deal with any emergencies and contingencies that may arise.

This application falls under Annex B and is approved on behalf of the ESC ☒

This application is referred to the ESC because it does not fall under Annex B ☐

This application is referred to the ESC because it requires independent scrutiny ☐

Signature(s):

Name(s) in block capitals: Marcello Costantini

Department: Psychology

Date: 9-Dec-16

The application has been approved by the ESC ☐

The application has not been approved by the ESC ☐

The application is referred to the University Ethics Committee ☐

Signature(s): ....

Name(s) in block capitals:...

Faculty: ....

Date: ....

Details of the Project

1.	**Brief outline of project** (This should include the purpose or objectives of the research, brief justification, and a summary of methods but should not include theoretical details. It needs to be understandable to a lay person, i.e. in everyday language that is free from jargon, and the reviewer must be able to understand what participants will be asked to do.).

This study is designed to investigate the effect of a mindfulness movement therapy programme (MMTP) on arm and hand function in patients with stroke and a control group of healthy adults. Healthy adults will be invited to partake either in a free 8-week course of MMTP (body scan, sitting meditation, and mindful-movement) or receive the programme of listening task and sitting meditation (control intervention group). The 8-week course will involve guided (following a CD) for 30 minutes, 3 times a week on non-consecutive days and monitoring compliance by Log book. Stroke patients will be recruited separately in Thailand, and tested in a hospital environment, for which separate ethical approval will be obtained. This ethics form only concerns recruitment and testing of the healthy adult control group, aged up to 70 years (N=32; 16 in each of 2 groups).

Participants will be tested before and after the course. They will be asked to complete questionnaires (the short-form Freiburg Mindfulness Inventory, The Hospital Anxiety and Depression Scale) and tests of hand and arm function (Fugl-Meyer Assessment, Action Research Arm Test). Transcranial magnetic stimulation (TMS) will measure motor function of the brain. For each participant, the study will take around 10 weeks (pre-intervention test, 8 weeks of intervention, post-intervention test). Depending on availability of participants (especially patients), the study will take up to two years to complete.

In this study, we will use paired-pulse TMS as a measure of intracortical excitability and construct motor maps of a hand muscle. For patients (not tested as part of this ethics application), this will allow us to identify cortical reorganization following stroke.

Paired pulse measures (SICI: short-interval intracortical inhibition; LICI: long-interval intracortical inhibition; and ICF: intracortical facilitation) are well-described parameters that provide information about intracortical excitability, and have been shown to correlate well with hand function at 3 months after stroke (Swayne et al., 2008). Paired-pulse TMS is considered a gold standard in testing the excitability of inhibitory and excitatory intracortical circuits within the human motor cortex (Cicinelli et al., 2003). SICI, LICI and ICF will be studied by use of a paired conditioning-test shock paradigm. The effect of the first (conditioning) stimulus on the second (test) stimulus is investigated at inter-stimulus intervals (ISI) of between 1 and 200 ms. The conditioning stimulus will set to a low intensity (5% below active motor threshold, aMT), whereas test pulse intensities are regulated 20% above the resting motor threshold (rMT). Each pair of stimuli will be delivered at a repetition rate ranging between 0.18 and 0.25 Hz (Cicinelli et al., 2003).

In addition, motor maps of muscles of the hand and arm (first dorsal interosseous, used for grip; extensor digitorum or ext. carpi ulnaris, used for wrist extension) will be constructed by acquiring 10 MEPs at a stimulation intensity of 110% rMT with 80 stimuli and a 1.5 s ISI that make it possible to acquire one map in a few minutes (Park et al., 2004; van de Ruit, 2015).

To acquire rMT, aMT and motor maps we will need to measure motor-evoked potentials (MEPs) from FDI, which requires the application of surface electrodes to the hand, and will be combined with (generic) neuronavigation data from the Brainsight 2 software.

The Neuroethics committee of the CBS/Dept. of Psychology (Drs Cooper, Gillmeister and Profs Russo, Romei) has reviewed this application and approved the procedure.

References:

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Participant Details

2. Will the research involve human participants? (indicate as appropriate)

Yes ☒ No ☐

3. Who are they and how will they be recruited? (If any recruiting materials are to be used, e.g. advertisement or letter of invitation, please provide copies).

Volunteers will be recruited through advertisement (see attached) at the University of Essex and through word of mouth. Participants will then be asked to provide written informed consent.

Will participants be paid or reimbursed?

Participation will be voluntary and in exchange for a free training course in either mindfulness movement therapy programme or listening task and sitting meditation (including free guidance CD and supplementary materials).

4. Could participants be considered:

(a) to be vulnerable (e.g. children, mentally-ill)? Yes ☐/ No ☒

(b) to feel obliged to take part in the research? Yes ☐/ No ☒

If the answer to either of these is yes, please explain how the participants could be considered vulnerable and why vulnerable participants are necessary for the research.

Informed Consent

5. Will the participant's consent be obtained for involvement in the research orally or in writing?[1] (If in writing, please attach an example of written consent for approval):

Yes ☒ No ☐

If in writing, please tick to confirm that you have attached an example of written consent ☒

Consent should be obtained before data is collected. How will consent be obtained and recorded? Who will be giving consent? Please indicate at what stage in the data collection process consent will be obtained. If consent is not possible, explain why.

Participants will voluntarily take part in this study after giving informed consent (see attached consent form) and in the knowledge they can withdraw from the study at any stage with no need to give a reason and without consequence.

The researcher will describe the experimental protocol (in lay terms) that will be used, the length of time involved, potential risks and discomforts, and answer any questions that the participant may have as well as providing the information sheet. The researcher will emphasize that the decision to take part in this study is voluntary and that participants can change their mind about taking part at any time without giving a reason, this is not a problem and there will be no penalty for withdrawing from the study. The researcher will also verbally describe the contents of the consent document and ensure that they understand its contents before giving them time to read it on their own before signing it. The researcher will again emphasize that signing the informed consent document does not commit them to participating in the study and that they are still free to withdraw at any time.

A Participant Information Sheet is enclosed.

Please attach a participant information sheet where appropriate.

Confidentiality / Anonymity

6. If the research generates personal data, describe the arrangements for maintaining anonymity and confidentiality or the reasons for not doing so.

[1] If the participant is not capable of giving informed consent on their own behalf or is below the age of consent, then consent must be obtained from a carer, parent or guardian. However, in the case of incompetent adults, the law in the United Kindom does not recognize proxy consent by a relative. In addition, the University Ethics Committee is not able to provide ethical approval for such research. It needs to be approved by a Health Research Authority National Research Ethics Service Research Ethics Committee.

Participants' personal information (name, age, sex etc.) will never be recorded together with the collected data, and names will never be stored in any format. Questionnaires and electronic data files will be number-coded and stored in this format. In published work either averaged data from a large sample of participants will be reported, or, should any individual's data be shown for illustration purposes or case reports, they will not be identified.

Data Access, Storage and Security

7. Describe the arrangements for storing and maintaining the security of any personal data collected as part of the project. Please provide details of those who will have access to the data.

Data stored coded by participant number only. Copies of data only stored on laboratory PCs, investigators' own PCs, and backup drives. Data accessed by investigators only.

It is a requirement of the Data Protection Act 1998 to ensure individuals are aware of how information about them will be managed. Please tick the box to confirm that participants will be informed of the data access, storage and security arrangements described above. If relevant, it is appropriate for this to be done via the participant information sheet ☒

Further guidance about the collection of personal data for research purposes and compliance with the Data Protection Act can be accessed at the following weblink. Please tick the box to confirm that you have read this guidance (http://www.essex.ac.uk/records_management/policies/data_protection_and_research.aspx) ☒

Risk and Risk Management[2]

8. Are there any potential risks (e.g. physical, psychological, social, legal or economic) to participants or subjects associated with the proposed research?

Yes ☒ No ☐

[2]Advice on risk assessment is available from the University's Health and Safety Advisers (email safety@essex.ac.uk; tel 2944) and on the University's website at www.essex.ac.uk/health-safety/risk/default.aspx.

If Yes,

Please provide full details of the potential risks and explain what risk management procedures will be put in place to minimise the risks:
In this study, TMS will measure recovery of the brain. The risks and associated ethical issues linked with the TMS procedure and described below. In the past 10 -15 years a large number of studies have used TMS. From 2003 to 2008, the amount of research on TMS led to about 3000 papers published in peer-reviewed journal in the fields of neurology, psychology, and psychiatry. It was found that TMS is a useful and safety device to evaluate the function of the human brain. It has been used extensively in clinical and research purposes (Rossi et al., 2009). TMS has the potential to cause seizures. However, it is a minimal risk factor, especially in people with no history of seizures. Researchers will strictly follow latest TMS safety guidelines; e.g. Rossi et al., 2009). These guidelines are set in terms of use and contraindications for safety of the participants, whether the intensity, frequency, and inter pulse train interval or the absolute number of pulses to be administered per testing session. The guidelines also provide directions for excluding participants with an individual or family history of seizures or other contraindications. To reduce the risk of TMS to a minimum, all participants have to complete a Safety Screening Questionnaire for Transcranial Magnetic Stimulation before enrolling in the study. If the participants answered "Yes" in the assessment form will be excluded from this study. The questionnaire consists of the safety screening questions from the recommendations in the literature reviewed by Keel et al. (2001) as well as those in the latest safety recommendations (Rossi et al., 2009). The screening form is included as part of this submission (see attached). In the unlikely event that a participant suffers a seizure, we shall focus on preventing complications, as recommended in the TMS safety guidelines (Wassermann,1998). The principal investigators who will administer the TMS procedure will have received first aid training, including training about seizure management. Seizure management will proceed according to the A-B-C rule: airway, breathing, circulation, which is common in other medical emergencies. In the unlikely event of a seizure, the researchers will also call the emergency first aid team of the University of Essex, who will attend and, if necessary, call an ambulance. The Neuroethics committee of the CBS/Dept. of Psychology (Drs Cooper, Gillmeister and Profs Russo, Romei) has reviewed this application and approved the TMS procedure. **Safety Guidelines and References:** Keel, J.C., Smith, M.J., &Wassermann, E.M. (2001). A safety screening questionnaire for transcranial magnetic stimulation. *Clinical Neurophysiology*,112(4), 720. Rossi, S., Hallet, M., Rossini, P.M., Pascual-Leone, A., & The Safety of TMS Consensus Group. (2009). Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research. *Clinical Neurophysiology*, 120, 2008-2039. Wassermann, E.M. (1998). Risk and safety of repetitive transcranial magnetic stimulation: report and suggested guidelines from the International Workshop on the Safety of ReptitiveTranscranial Magnetic Stimulation, June 5-7, 1996. *Electroencephalography and Clinical Neurophysiology*, 108, 1-16. Please find enclosed a TMS safety Questionnaire.

9. Are there any potential risks to researchers as a consequence of undertaking this proposal that are greater than those encountered in normal day-to-day life?

Yes ☐ No ☒

If Yes,

Please provide full details and explain what risk management procedures will be put in place to minimise the risks:

10. Will the research involve individuals below the age of 18 or individuals of 18 years and over with a limited capacity to give informed consent?

Yes ☐ No ☒

If Yes, a Disclosure and BarringService disclosure (DBS check) may be required.[3]

11. Are there any other ethical issues that have not been addressed which you would wish to bring to the attention of the Faculty Ethics Sub-Committee and/or University Ethics Committee.

No

[3]Advice on the Disclosure and Barring Service and requirement for checks is available: (1)for staff from Employment Compliance Manager in Human Resources (email lauren@essex.ac.uk; tel 3508) and on the University's website athttp://www.essex.ac.uk/hr/policies/docs/CRBdocumentpolicy.pdf; (2) for students from the University's Academic Section.

Appendix III. Full search strategy: search strategy example (MEDLINE 1946 to June 2018).

#	Query	Results
S29	S8 AND S28	342
S28	S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27	17,138
S27	(mbsr$ or mbct$)	759
S26	mindfulness based$	2,176
S25	mbct*	343
S24	mbsr*	524
S23	mbi*	8,068
S22	mindfulness based cognitive therapy$	507
S21	mindfulness based stress reduction	706
S20	mindfulness based intervention$	363
S19	mindfulnes*	5,128
S18	meditation$	4,778
S17	meditat*	5,628
S16	Zen meditation	78
S15	vipassana meditation	30
S14	(Vipassana meditation or Zen meditation)	103
S13	mindfulness meditation	852
S12	mindfulness	5,127
S11	(MH "Mindfulness")	1,708
S10	Meditation/	4,778
S9	(MH "Meditation")	2,237
S8	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7	593,334
S7	(hemipleg$ or hemipar$ or paresis or paretic)	16,628
S6	hemiplegia/ or exp paresis/	14,700
S5	((brain$ or cerebr$ or cerebell$ or intracerebral or intracranial or subarachnoid) adj5 (haemorrhage$ or hemorrhage$ or haematoma$ or hematoma$ or bleed$))	1
S4	((brain$ or cerebr$ or cerebell$ or intracran$ or intracerebral) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$))	1
S3	(stroke or poststroke or post-stroke or cerebrovasc$ or brain vasc$ or cerebral vasc$ or cva$ or apoplex$ or SAH)	270,371
S2	(MH "Stroke+")	112,474
S1	(MH "Cerebrovascular Disorders+")	329,060

Appendix IV. A logbook of the mindfulness movement therapy programme group

LOG BOOK 1

Mindfulness Movement Therapy for Upper Extremities in Healthy Older Adults: A Pilot Protocol

8 WEEK COURSE LOG BOOK

Contents

1. CD Contents

CD1

1. Upper Extremity Body Scan Meditation (10 minutes)
2. Sitting Meditation (10 minutes)
3. Mindful-movement Meditation (10 minutes)

Mindfulness is the awareness that emerges
when we pay attention in a particular way;
on purpose,
in the present moment,
and non-judgementally
to things as they are...

Jon Kabet-Zinn

2. About the mindfulness movement therapy programme

Mindfulness movement therapy consisting of body scan, sitting meditation, and mindful-movement meditation guided by CD for 30 minutes, 3 times a week on non-consecutive days, for 8 weeks

Arrange to spend the time doing this meditation on a regular basis in a warm and safe place, in which you feel comfortable and secure. It is best to do it at a time when you will not be interrupted by family, pets or phone calls. Dress in loose and comfortable clothing in particular makes sure your clothes do not feel tight around your waist, or restrict your breathing. Allowing this to be the time in which you set aside the usual mode in which you operate, that of more or less constant doing, and switch to a mode of non doing. A mode of simply being, of allowing yourself to be, of becoming aware of your being. There are several longer periods of silence in this meditation. It will be useful if, during these periods of silence, you can draw on your ability to be mindful.

2.1 Body-Scan Meditation

The Body-scan meditation is based on a Mindfulness-Based Stress Reduction programme created by Jon Kabat-Zinn at the University of Massachusetts Medical Centre.

A major aim of body scan practice is to bring detailed awareness to each part of the body however in this study the focus is specifically on the non-dominant upper extremity, as you scan from your fingers to your shoulder. You will first learn to keep your attention focused over a sustained period of time that nurtures and develops greater stability of mind, calmness, and mindfulness. Be aware of each passing moment, remember that there is no right way to feel while you are doing this, the way you are feeling is the way you are feeling right now and accept whatever is happening in yourself. Remind yourself of the intention of this practice. Its aim is not to feel any different, relexed, or calm; this may happen or it may not. Instead, the intention of the practice is to bring awareness to any sensations you detect, as you focus your attention on each part of the body in turn. Just do it with an attitude of openness and curiosity, then allow the rest to take care of itself.

Your mind will inevitably wander away from the breath and the body from time to time. That is entirely normal. It is what minds do. Just watch the activity of your mind, letting go of judgmental and critical thoughts when they arise. When you notice it, gently acknowledge it, noticing where your mind has gone off to, and then gently return your attention to the part of the body you intended to focus on and just doing what the exercise guides you to do as best you can.

Keep in mind that body scan is more to aid in the cultivation of awareness than an attempt simply to be relaxed so you should stay awake. It is best if you can manage to stay awake throughout the entire exercise. The intention is to "fall awake" rather than to fall asleep. If you find yourself falling asleep, you might find it helpful to open your eyes. So if you have trouble staying awake, try doing the body scan with your eyes open. So it is best not to do this when you are very tired.

Starting position

Sitting a straight back on a chair and put a pillow behind to make yourself comfortable. Rest your right hand on your thigh then place your left arm on the table in front of you, palm facing towards the ceiling, ankles uncrossed and your feet fully supported on the floor (Figure 1).

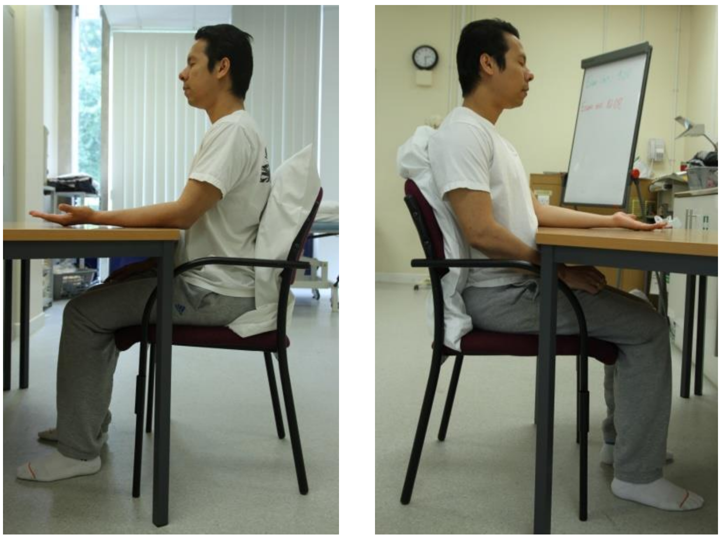


Figure 1: Body scan meditation posture

2.2 Sitting Meditation

Sitting meditation is based on Mindfulness-Based Stress Reduction programme that was created by Jon Kabat-Zinn at the University of Massachusetts Medical Centre.

Focusing on the sensation of the breath moving past the nostrils or alternatively on the feeling of your belly expanding on each in breath and receding gently with each out breath. And allow yourself to just dwell here moment by moment, following the breath as it comes in and as it goes out. This means choosing as best you can not to react to or judge any of your thoughts or feelings, impulses or perceptions. Reminding yourself instead that in this work of mindfulness, absolutely anything that comes into the field of awareness is okay, we simply sit with it and breathe with it, and observe it, staying open and awake in the present moment, right here, right now, a continual process of seeing and letting be, seeing and letting go, rejecting nothing, pursuing nothing, dwelling in stillness and in calmness, as the breath moves in and out. And bringing your attention back to the nostrils or to your belly, or anywhere else you have decided to focus on each time that you notice that your mind has gone off somewhere else, wherever that may be. And if the mind wanders off a thousand times, you simply bring it back a thousand times. Intentionally cultivating an attitude of patience and gentleness towards yourself. In this way you are cultivating your natural ability to concentrate your mind. By repeatedly bringing your attention back to the breath each time it wanders off, concentration builds and deepens, much as muscles develop by repetitively lifting weights.

For sitting meditation on a chair, the ideal is to use one that has a straight back and that allows your feet to be flat on the floor. If possible, sit away from the back of the chair so that your spine is self-supporting (Figure 2). But if you have to, leaning against the back of the chair is also fine. It can be an outward support in cultivating an inner attitude of dignity, patience, presence, and self-acceptance. The main points to keep in mind about your posture are to keep the back, neck, and head aligned vertically to whatever degree possible, to relax the shoulders, and to do something comfortable with your hands. Perhaps place them on your knees. This allows the breath to flow most easily.

Figure 2: Sitting meditation posture

As a rule, if you sit still for a while in any position, your body will become uncomfortable. The best way to explore sensation of pain and disfomfort is to welcome them when they arise rather than resisting them or trying to make them go away because you don't like them. By sitting with some discomfort and accepting it as part of your experience in the present moment, even if you don't like it, which you don't, you discover that it is actually possible to turn toward and relax into physical discomfort, to embrace it in awareness as it is. You breathe with the sensations. You breathe into them. You put out the welcome mat for them and actually try to maintain a continuity of awareness from moment to moment in their presence. It is actually useful to resist the first impulse to shift position in response to bodily discomfort. Then, if you have to, shift your body to reduce the discomfort, but even that do mindfully, with moment-to-moment awareness as you are moving the body

Aside from physical discomfort and pain, there are numerous other occurrences during meditation that can carry your attention away from the breath. The primary one is thinking. During meditation, we intentionally treat all our thoughts as if they are of equal value. As best we can, and with the lightest of touches, we bring awareness to them when they arise, and then we intentionally return our attention to the breath as the primary focus of our attention, regardless of the content of the thought and its emotional charge. It might help to keep in mind that the awareness of our thoughts and emotions is the same awareness as the awareness of our breathing.

2.3 Mindful-movement meditation

Mindful-movement practice is based on active range of motion of the upper extremities as the formal meditation practice. Formal practices cultivate greater mindfulness of the body in movement. The point of mindful-movement is not physical strengthening. It is just another opportunity to become aware of your body.

Use the movement and sensations of active range of motion of the left upper extremity to bring yourself into the present. The focus is on maintaining moment-to-moment awareness of the sensations accompanying your movements. Bring your attention to the actual experience of upper extremity movement as you are engaged in it. It means simply movement and knowing that you are moving. It dose not mean looking at your arm. You should move slowly, so that you can really experience the various aspects of upper extremity movement and attend to the particular sensations that you are focusing on.

As with all the other mindfulness practice, when the mind wanders away from the feeling of the upper extremity movement, you simply notice what is on your mind in that moment and then gently bring your mind back to where you are in the movement.

Starting Position

Lie down on your back, palm facing the ceiling and put pillows under your head. Then move the pillows to the right side in order to free your left shoulder movement. Put the pillows under your knees to reduce tension of your back (Figure 3 – 5). This should make you comfortable and able to easily pay attention to do mindful-movement of the left upper extremity.

Figure 3: Lie on your back fully supported with the pillows

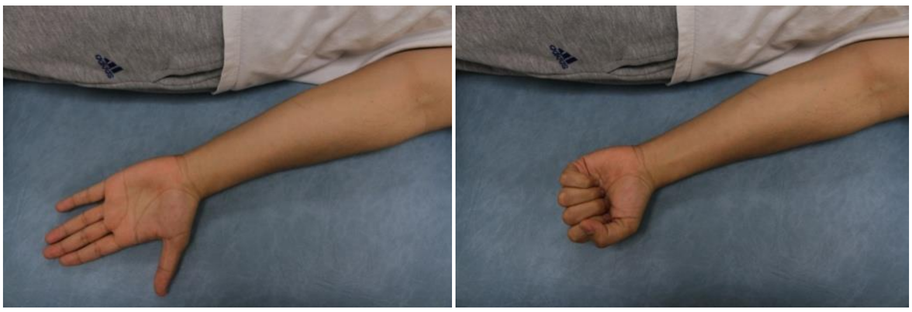
Figure 4: Move the pillows to the right side

Figure 5: Put the pillows under your knees to reduce tension in your back

Mindful-movement meditation of upper extremity

There are nine mindful-movement positions consisting of mindful-movements of the fingers, wrist, elbow, and shoulder, respectively. Each mindful-movement position should take around 30 second.

1. Finger flexion/extension



2. Wrist flexion/extension

3. Elbow pronation/supination.

4. Elbow flexion/extension.

5. Shoulder flexion/extension.

6. Shoulder abduction/adduction.

7. Shoulder internal / external rotation.

8. Upper extremity functional movement of PNF pattern D1F/D1E.

9. Upper extremity functional movement of PNF pattern D2F/D2E.

3. Practice Journal Page

Please tick to confirm you have undertaken the required practice. If you would like to make any comments about the experience, please do so.

	Body Scan	Sitting meditation	Mindful-movement
Week 1 Day 1/1			
Day 2/2			
Day 3/3			
Week 2 Day 1/4			
Day 2/5			
Day 3/6			

	Body Scan	Sitting meditation	Mindful-movement
Week 3 Day 1/7			
Day 2/8			
Day 3/9			
Week 4 Day 1/10			
Day 2/11			
Day 3/12			

	Body Scan	Sitting meditation	Mindful-movement
Week 5 Day 1/13			
Day 2/14			
Day 3/15			
Week 6 Day 1/16			
Day 2/17			
Day 3/18			

	Body Scan	Sitting meditation	Mindful-movement
Week 7 Day 1/19			
Day 2/20			
Day 3/21			
Week 8 Day 1/22			
Day 2/23			
Day 3/24			

Appendix V. A logbook of the active control group.

LOG BOOK 2

Mindfulness Movement Therapy for Upper Extremities in Healthy Older Adults: A Pilot Protocol

WEEK COURSE LOG BOOK

Contents

1. CD Contents

CD 2

1. Cognitive task (10 minutes)
2. Sitting Meditation (20 minutes)

Mindfulness is the awareness that emerges
when we pay attention in a particular way;
on purpose,
in the present moment,
and non-judgementally
to things as they are...

Jon Kabet-Zinn

2. About the mindfulness therapy programme

Mindfulness therapy programme consisting of cognitive task and sitting meditation guided by CD for 30 minutes, 3 times a week on non-consecutive days, for 8 weeks

Arrange to spend the time doing this programme on a regular basis in a warm and safe place, in which you feel comfortable and secure. It is best to do it at a time when you will not be interrupted by family, pets or phone calls. Dress in loose and comfortable clothing in particular makes sure your clothes do not feel tight around your waist, or restrict your breathing. Allowing this to be the time in which you set aside the usual mode in which you operate, that of more or less constant doing, and switch to a mode of non doing. A mode of simply being, of allowing yourself to be, of becoming aware of your being. There are several longer periods of silence in this meditation. It will be useful if, during these periods of silence, you can draw on your ability to be mindful.

2.1 Cognitive task

The cognitive task is a talk about human anatomy of bones and muscles of the arms and hands written by Professor John K. Young at the Howard University, College of Medicine. You will listen this for 10 minutes.

Starting position

Sitting a straight back on a chair and put a pillow behind to make yourself comfortable. Rest your right hand on your thigh then place your left arm on the table in front of you, palm facing towards the ceiling, ankles uncrossed and your feet fully supported on the floor (Figure 1).

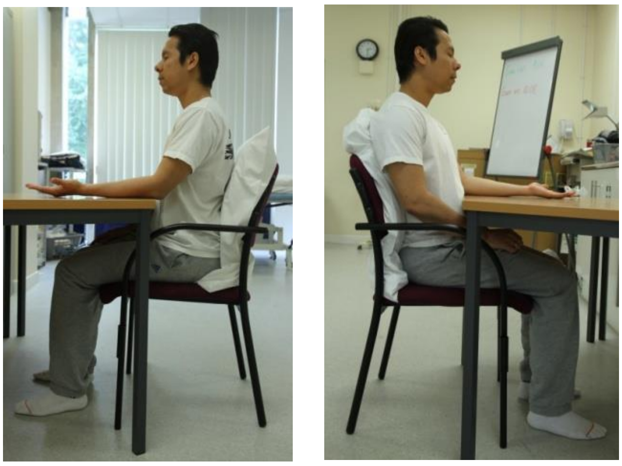


Figure 1: Starting position of cognitive task

2.2 Sitting Meditation

Sitting meditation is based on Mindfulness-Based Stress Reduction programme that was created by Jon Kabat-Zinn at the University of Massachusetts Medical Centre.

Focusing on the sensation of the breath moving past the nostrils or alternatively on the feeling of your belly expanding on each in breath and receding gently with each out breath. And allow yourself to just dwell here moment by moment, following the breath as it comes in and as it goes out. This means choosing as best you can not to react to or judge any of your thoughts or feelings, impulses or perceptions. Reminding yourself instead that in this work of mindfulness, absolutely anything that comes into the field of awareness is okay, we simply sit with it and breathe with it, and observe it, staying open and awake in the present moment, right here, right now, a continual process of seeing and letting be, seeing and letting go, rejecting nothing, pursuing nothing, dwelling in stillness and in calmness, as the breath moves in and out. And bringing your attention back to the nostrils or to your belly, or anywhere else you have decided to focus on each time that you notice that your mind has gone off somewhere else, wherever that may be. And if the mind wanders off a thousand times, you simply bring it back a thousand times. Intentionally cultivating an attitude of patience and gentleness towards yourself. In this way you are cultivating your natural ability to concentrate your mind. By repeatedly bringing your attention back to the breath each time it wanders off, concentration builds and deepens, much as muscles develop by repetitively lifting weights.

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Figure 2: Sitting meditation posture

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3. Practice Journal Page

Please tick to confirm you have undertaken the required practice. If you would like to make any comments about the experience, please do so.

	Cognitive task	**Sitting meditation**
Week 1 Day 1/1		
Day 2/2		
Day 3/3		

	Cognitive task	Sitting meditation
Week 2 Day 1/4		
Day 2/5		
Day 3/6		
Week 3 Day 1/7		
Day 2/8		
Day 3/9		

	Cognitive task	Sitting meditation
Week 4 Day 1/10		
Day 2/11		
Day 3/12		
Week 5 Day 1/13		
Day 2/14		
Day 3/15		

	Cognitive task	Sitting meditation
Week 6 Day 1/16		
Day 2/17		
Day 3/18		
Week 7 Day 1/19		
Day 2/20		
Day 3/21		

	Cognitive task	Sitting meditation
Week 8 Day 1/22		
Day 2/23		
Day 3/24		

Appendix VI. Research Ethics Committee number

Effective date: 1 Jan 2017 AL-011_ENG

FACULTY OF MEDICINE

Human Research Ethics Committee
Faculty of Medicine, Prince of Songkla University

This document is a record of review and approval/acceptance of clinical study protocol.

REC	60-121-30-2
Protocol Title	The Effect of Mindfulness Movement Therapy Programme on the Motor Performance of the Upper Limbs in Healthy Older Adults: A Randomized Single-Blind Controlled Trial
Principal Investigator	Mr.Weeranan Yaemrattanakul
Affiliation	Department of Physical Therapy, Faculty of Medicine, Prince of Songkla University
Co-investigator	Sittipong Tipchatyotin, MD
Affiliation	Department of Orthopaetic and Physical Medicine, Faculty of Medicine, Prince of Songkla University

Approved documents:

1. Submission form version 2.0 date July 6, 2017
2. Study protocol version 2.0 date July 6, 2017
3. Participant information sheet version 2.0 date July 6, 2017
4. Informed consent form version 2.0 date July 6, 2017
5. Clinical record form
6. Logbook
6. Curriculum Vitae

have/has been reviewed and approved by Human Research Ethics Committee, Faculty of Medicine Prince of Songkla University in full compliance with International Guidelines for human research subject protection such as Declaration of Helsinki, Belmont Report, CIOMS Guideline and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

This review is documented in the meeting minutes of the meeting 16/2017, panel 2 .agenda 4.2.01 on June 6, 2017

Please submit the Progress Report every 12 months. (Renewal must be submitted at least 30 days prior to expired date.)

....

(Associate Professor Boonsin Tangtrakulwanich, M.D. PhD.)
Chairman of Human Research Ethics Committee

Date of Approval: July 13, 2017
Date of Expiration: July 12, 2018

Human Research Ethics Committee
Faculty of Medicine, Prince of Songkla University
15 Karnchanavanich Road, Hat Yai, Songkla 90110, Thailand
Tel. 66 7445-1149, 66 7445-1157 Fax: 66 7421-2900

Appendix VII. A safety screening questionnaire for TMS.

University of Essex
Department of Psychology
Centre for Brain Science
Wivenhoe Park, Colchester
CO4 3SQ, United Kingdom

Safety Screening Questionnaire for Transcranial Magnetic Stimulation (TMS)
(Version 1.1, Jan08 2013)

Participant Name: ______________________________ **Date:** ______________

Current Age: _____ (in years) **Handedness:** Left Right Ambi

Have you ever had an adverse reaction to TMS?	☐Yes	☐No
Do you have epilepsy or have you ever had a seizure/convulsion?	☐Yes	☐No
Have you ever had a fainting spell or syncope? If yes, describe.	☐Yes	☐No
Have you ever had a stroke?	☐Yes	☐No
Have you ever had a serious head injury (with loss of consciousness)?	☐Yes	☐No
Have you ever had neurosurgery of any type (including brain or spinal cord)?	☐Yes	☐No
Do you have hearing problems or ringing in your ears?	☐Yes	☐No
Do you have any metal in your body such as shrapnel, surgical clips, or fragments from welding or metalwork?	☐Yes	☐No
Do you have any implanted devices such as cardiac pacemakers, aneurysm clips, cochlear implants, medical pumps, deep brain stimulators, or intracardiac lines?	☐Yes	☐No
Do you have a medication infusion device	☐Yes	☐No
Do you suffer from frequent or severe headaches?	☐Yes	☐No
Have you ever had any other brain-related condition?	☐Yes	☐No
Have you ever had any illness that caused brain injury?	☐Yes	☐No
Are you taking any psychiatric or neuroactive medications? (please list)	☐Yes	☐No
Are you taking any other medications or other drugs/substances?	☐Yes	☐No
Are you pregnant or do you have any reason to believe that you may be?	☐Yes	☐No
Do you, or does any family member, have epilepsy/history of seizures?	☐Yes	☐No
Do you hold a heavy goods vehicle driving license or bus license?	☐Yes	☐No
Have you consumed alcohol in the past 24 hours?	☐Yes	☐No
Did you have adequate sleep last night?	☐Yes	☐No
Have you participated in a TMS study within the past 24 hours?	☐Yes	☐No

Potential Contraindication Drugs

Strong Potential Hazard: Imipramine, amitriptyline, doxepine, nortriptyline, maprotiline, chlorpromazine, clozapine, foscarnet, ganciclovir, ritonavir, amphetamines, cocaine, (MDMA, ecstasy), phencyclidine (PCP, angel's dust), ketamine, gamma-hydroxybutyrate (GHB), alcohol, theophylline

Relative Potential Hazard:mianserin, fluoxetine, fluvoxamine, paroxetine, sertraline, citalopram, reboxetine, venlafaxine, duloxetine, bupropion, mirtazapine, fluphenazine, pimozide, haloperidol, olanzapine, quetiapine, aripiprazole, ziprasidone, risperidone, chloroquine, mefloquine, imipenem, penicillin, ampicillin, cephalosporins, metronidazole, isoniazid, levofloxacin, cyclosporin, chlorambucil, vincristine, methotrexate, cytosine arabinoside, BCNU, lithium, anticholinergics, antihistamines, sympathomimetics.

Withdrawl Hazard: alcohol, barbiturates, benzodiazepines, meprobamate, chloral hydrate.

Appendix VIII. A logbook of the mindfulness movement therapy programme group for Thai older adults.

สมุดคู่มือ

ผลของโปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างมีสติต่อประสิทธิภาพ

การเคลื่อนไหวของรยางค์แขน ในผู้สูงอายุสุขภาพดี โดยการทดลองปกปิดแบบสุ่ม

หลักสูตร 8 สัปดาห์

สารบัญ

1. แผ่นซีดีโปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างมีสติ

ลำดับที่ 1 การสแกนร่างกาย

ลำดับที่ 2 การนั่งสมาธิ

ลำดับที่ 3 การเคลื่อนไหวอย่างมีสติ

2. โปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างมีสติ

โปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างมีสติประกอบด้วย 1) การสแกนร่างกาย 2) การนั่งสมาธิ และ 3) การเคลื่อนไหวอย่างมีสติ โดยเป็นการฝึกปฏิบัติตามแผ่นซีดี ประมาณ 30 นาทีต่อครั้ง 3 ครั้งต่อสัปดาห์ โดยพยายามให้วันในการฝึกปฏิบัติไม่ติดกัน เช่น วันจันทร์ วันพุธ วันศุกร์ เป็นเวลา 8 สัปดาห์ หลังจากนั้นกลับมาวัดผลหลังโปรแกรมครั้งที่ 1 และฝึกต่อเนื่องไปอีก 8 สัปดาห์ และกลับมาวัดผลหลังโปรแกรมครั้งที่ 2

โดยท่านต้องวางแผนในการฝึกปฏิบัติโปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างมีสติอย่างสม่ำเสมอ โดยเลือกสถานที่ที่ท่านรู้สึกสะดวกสบาย ปลอดภัยและเป็นช่วงเวลาที่ไม่ถูกรบกวนจากสมาชิกในครอบครัว สัตว์เลี้ยงหรือโทรศัพท์ ขณะปฏิบัติพยายามใส่เสื้อผ้าที่หลวมและสบาย ไม่รัดหน้าท้องหรือหน้าอกจนจำกัดการหายใจ

2.1 การสแกนร่างกาย

การสแกนร่างกายอยู่บนพื้นฐานของโปรแกรมการบำบัดด้วยการฝึกสติเพื่อลดความเครียด ซึ่งพัฒนาโดย ศาสตราจารย์ดอกเตอร์จอน คาแบต-ซินน์ ที่ศูนย์การแพทย์ของมหาวิทยาลัยแมสซาชูเซตส์ ประเทศสหรัฐอเมริกา

เป้าหมายหลักของการสแกนร่างกายคือการนำความรู้สึกตัวไปสู่ส่วนต่างๆของร่างกาย โดยในการศึกษาครั้งนี้จะเน้นเฉพาะแขนข้างไม่ถนัด โดยจะให้ท่านสแกนจากนิ้วมือไปจนถึงข้อไหล่ ท่านจะได้เริ่มต้นในการเรียนรู้ที่จะพยายามจดจ่ออยู่กับสิ่งใดสิ่งหนึ่ง ซึ่งเป็นการฝึกฝนและพัฒนาความตั้งมั่นของจิต ความสงบและสติให้มากขึ้น มีความรู้สึกตัวอยู่กับปัจจุบัน รับรู้ความรู้สึกที่เกิดขึ้นในขณะนั้นและยอมรับความรู้สึกทุกอย่างที่เกิดขึ้น ให้ท่านเตือนตัวเองเสมอว่าจุดประสงค์ของการฝึกไม่ได้ต้องการให้ท่านมีความรู้สึกแปลกประหลาด อัศจรรย์ ผ่อนคลายหรือสงบ ความรู้สึกเหล่านี้อาจจะเกิดขึ้นหรือไม่เกิดขึ้นก็ได้ แต่ความตั้งใจของการฝึกคือการนำความรู้สึกตัวไปรับรู้ความรู้สึกต่างๆ ที่เกิดขึ้นตามที่มันเป็น ขณะที่ท่านเอาความรู้เนื้อรู้ตัวไปจดจ่อที่ส่วนต่างๆของร่างกาย เป็นเรื่องปกติที่จิตของเราจะแว๊บออกไปข้างนอกเป็นระยะๆ โดยไม่ได้อยู่กับลมหายใจหรือร่างกาย เป็นธรรมดาของจิต ท่านเพียงแค่เฝ้าดูการทำงานของจิต โดยไม่เข้าไปตัดสินหรือคิดวิเคราะห์ เมื่อท่านระลึกรู้ได้ว่าจิตส่งออกไปข้างนอก ให้ท่านค่อยๆดึงจิตกลับมาอยู่กับส่วนของร่างกาย ที่ท่านกำลังฝึกปฏิบัติอยู่ ตามที่ซีดีแนะนำ การสแกนร่างกายเป็นการช่วยพัฒนาความรู้สึกตัวมากกว่าการพยายามให้ท่านรู้สึกผ่อนคลาย ดังนั้นจะเป็นการดีที่สุดหากท่านสามารถจัดการให้ตื่นได้ตลอดช่วงของการฝึก ความตั้งใจของการฝึกคือการตื่นรู้ มากกว่าการหลับ หากท่านรู้สึกง่วงขณะฝึก ท่านสามารถลืมตาฝึกได้ ฉะนั้นท่านไม่ควรฝึกสแกนร่างกายขณะที่รู้สึกเหนื่อยล้า

ท่าเริ่มต้นในการสแกนร่างกาย

นอนหงายหมอนรองใต้เข่า จัดตัวเองให้อยู่ในท่าที่สบาย ผ่อนคลาย ปลายเท้าแยกจากกันเล็กน้อย วางมือทั้งสองไว้ข้างลำตัว หงายฝ่ามือขึ้น ปล่อยให้มืออยู่ในลักษณะกึ่งกำกึ่งเหยียด ในท่าที่สบาย (รูปที่ 1) เมื่อท่านพร้อมแล้วก็ให้เปิดซีดีลำดับที่ 1 ปฏิบัติการสแกนร่างกาย เป็นเวลา 10 นาที

รูปที่ 1 ท่าเริ่มต้นในการสแกนร่างกาย

2.2 การนั่งสมาธิ

การนั่งสมาธิอยู่บนพื้นฐานของโปรแกรมการบำบัดด้วยการฝึกสติเพื่อลดความเครียด ซึ่งพัฒนาโดย ศาสตราจารย์ดอกเตอร์จอน คาแบต-ซินน์ ที่ศูนย์การแพทย์ของมหาวิทยาลัยแมสซาชูเซตส์ ประเทศสหรัฐอเมริกา

ในการนั่งสมาธิให้ท่านนำความรู้สึกตัวไปอยู่กับลมหายใจที่เคลื่อนผ่านรูจมูกหรือหากท่านไม่ถนัดให้ท่านนำความรู้สึกตัวไปอยู่กับการพองยุบของหน้าท้องแทน โดยให้ท่านอยู่กับลมหายใจในแต่ละขณะ เฝ้าติดตามดูลมหายใจเข้าและลมหายใจออก ให้ท่านเตือนตัวเองเสมอว่าในการฝึกสมาธินั้นไม่ว่าอะไรก็ตามที่เข้ามาก็แค่รับรู้ตามที่มันเป็น ไม่เข้าไปตัดสินว่าถูกหรือผิด ไม่คำนึงถึงเนื้อหาของความคิดและความรู้สึกของอารมณ์ เพียงแค่นั่งอยู่ตรงนี้ อยู่กับลมหายใจเข้าออก เฝ้าสังเกตุด้วยความตื่นรู้ในปัจจุบันขณะ เพียงแค่เห็นแล้วปล่อยมันไป ไม่ต่อต้าน ไม่มีอะไรต้องตามหา อยู่ตรงนี้ ที่นี่ด้วยใจสงบนิ่ง อยู่กับลมหายใจเข้า ลมหายใจออก เมื่อไหร่ก็ตามที่ท่านระลึกรู้ได้ว่า จิตของท่านแว๊บออกไปข้างนอก ให้ท่านนำจิตกลับมาอยู่กับลมหายใจหรือการพองยุบของหน้าท้อง หากจิตของท่านแว๊บออกไปพันครั้ง ท่านก็นำจิตกลับมาอยู่กับลมหายใจพันครั้ง เป็นการฝึกความสามารถในการมีสมาธิตามธรรมชาติ โดยการฝึกให้ท่านกลับมาอยู่กับลมหายใจซ้ำๆ ทุกครั้งที่จิตแว๊บออกไปข้างนอก ทำให้ท่านมีสมาธิที่ตั้งมั่นมากขึ้นซึ่งเหมือนกับการออกกำลังกายเพื่อเพิ่มความแข็งแรงของกล้ามเนื้อที่ท่านต้องออกกำลังกาย ยกน้ำหนักซ้ำๆ เช่นกัน

การนั่งสมาธิให้นั่งบนเก้าอี้ ตัวตรง หลังตรง โดยให้เท้าวางราบกับพื้น ถ้าเป็นไปได้พยายามอย่านั่งพิงพนัก เพื่อให้หลังเหยียดตรง หากท่านจำเป็นต้องนั่งพิงพนักเก้าอี้ก็ต้องพยายามนั่งให้ศีรษะ

คอและหลังอยู่ในแนวตั้งตรงที่สุดเท่าที่จะสามารถทำได้ ผ่อนคลายบ่าและไหล่ วางมือบนหน้าตักในท่าที่สบาย ท่าทางการนั่งแบบนี้จะทำให้ท่านหายใจได้โล่งขึ้น (รูปที่ 2)

รูปที่ 2 ท่าทางการนั่งสมาธิ

เป็นธรรมดาเมื่อท่านนั่งอยู่ในท่าใดท่าหนึ่งเป็นเวลานาน จะทำให้เกิดอาการปวดเมื่อยขึ้นได้ ทางที่ดีที่สุดในการจัดการกับความรู้สึกปวดเมื่อยหรือความไม่สุขสบายเหล่านั้นคือการรู้สึกยินดีต้อนรับความรู้สึกเหล่านั้น แทนที่จะต่อต้านหรือพยายามที่จะผลักไสความรู้สึกเหล่านั้นให้มันหายไปเพราะความรู้สึกไม่ชอบ การนั่งอยู่กับความรู้สึกปวดเมื่อยและยอมรับมันเข้ามาเป็นส่วนหนึ่งของประสบการณ์ของท่านในปัจจุบัน ถึงแม้ท่านจะรู้สึกไม่ชอบ ท่านอาจจะพบว่ามันเป็นไปได้ที่ท่านจะสามารถนั่งอยู่กับความรู้สึกเหล่านี้ด้วยใจที่สงบและยอมรับมันตามที่มันเป็น ให้ท่านหายใจอยู่กับความรู้สึกเหล่านี้ หายใจเข้าไปยังส่วนที่ทำให้ท่านรู้สึกปวด และพยายามรักษาความรู้เนื้อรู้ตัวให้อยู่กับปัจจุบัน หากท่านต้องการที่จะขยับหรือเปลี่ยนท่าเพื่อลดอาการปวดเมื่อย จะเป็นประโยชน์มากหากท่านพยายามฝึกต้านแรงกระตุ้นแรกที่ท่านรู้สึกต้องการขยับเพื่อเปลี่ยนท่า และเมื่อท่านต้องเปลี่ยนท่าให้ท่านทำด้วยความรู้สึกตัว อยู่กับการเคลื่อนไหวตลอดการเปลี่ยนท่า

2.3 การเคลื่อนไหวอย่างมีสติ

การฝึกการเคลื่อนไหวอย่างมีสติโดยการเคลื่อนไหวส่วนของแขนและมือ จุดประสงค์ของการฝึกไม่ได้ต้องการเพิ่มความแข็งแรงของกล้ามเนื้อ แต่เป็นอีกรูปแบบหนึ่งของการฝึกสมาธิโดยใช้การเคลื่อนไหวเป็นเครื่องมือในการนำท่านให้กลับมาอยู่กับปัจจุบัน นำความรู้สึกตัวไปอยู่กับการเคลื่อนไหวในส่วนของแขนและมือ รับรู้ถึงการเคลื่อนไหวในทุกขณะโดยไม่ใช้การมองเห็น ท่านจึงต้องเคลื่อนไหวอย่างช้าๆ เพื่อที่จะสามารถอรับรู้การเคลื่อนไหวได้ทุกส่วนของแขนและมือ เช่นเดียวกับ

การฝึกสมาธิในรูปแบบอื่น เมื่อจิตของท่านออกไปข้างนอก เมื่อท่านระลึกรู้ได้ก็ให้ดึงกลับมาอยู่กับการเคลื่อนไหวในขณะนั้น

ท่าเริ่มต้นในการฝึกการเคลื่อนไหวอย่างมีสติ

นอนหงาย หมอนรองใต้ศีรษะและขยับหมอนไปทางด้านข้างเล็กน้อยเพื่อให้แขนสามารถเคลื่อนไหวได้เต็มช่วง วางแขนทั้งสองไว้ข้างลำตัว หงายฝ่ามือขึ้น หมอนรองใต้เข่าเพื่อให้หลังผ่อนคลาย (รูปที่ 3 – 5) ท่าทางเหล่านี้จะทำให้ท่านรู้สึกสบายและสามารถมุ่งความสนใจไปเฉพาะการเคลื่อนไหวในส่วนของแขนและมืออย่างมีสติได้ง่ายขึ้น

รูปที่ 3 ท่าเริ่มต้นในการฝึกการเคลื่อนไหวอย่างมีสติ

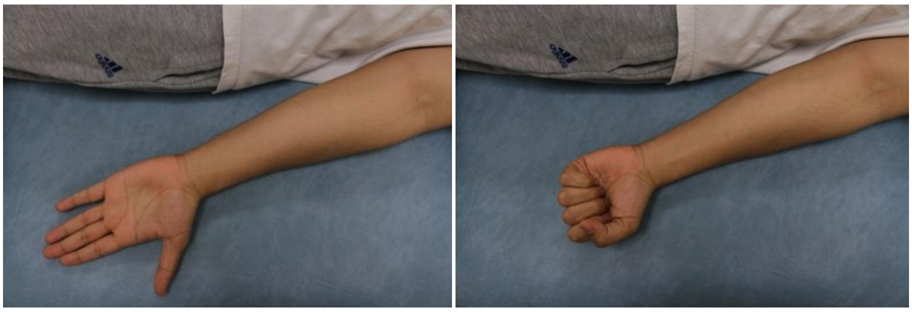
รูปที่ 4 ขยับหมอนไปทางด้านข้างเล็กน้อยเพื่อเปิดโอกาสให้แขนสามารถเคลื่อนไหวได้เต็มช่วง

รูปที่ 5 วางหมอนใต้เข่าเพื่อลดแรงตึงที่หลัง

การเคลื่อนไหวอย่างมีสติในส่วนของแขนและมือ

การเคลื่อนไหวอย่างมีสติมีทั้งหมด 9 ท่า ประกอบด้วยการเคลื่อนไหวของนิ้วมือ ข้อมือ ข้อศอกและข้อไหล่ ในแต่ละท่าให้ท่านฝึกท่าละประมาณ 30 วินาที ตามที่แผ่นซีดีแนะนำ

1. การกำและแบนิ้วมือ



2. การกระดกข้อมือขึ้นลง

3. การคว่ำและหงายฝ่ามือ

4. การงอและเหยียดข้อศอก

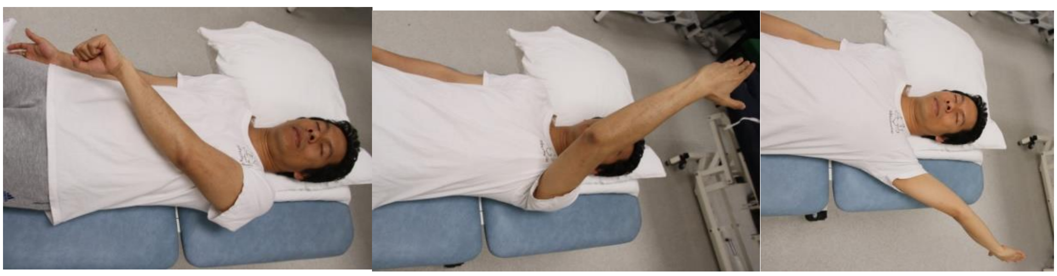
5. การยกแขนขึ้นลง

6. การกางและหุบแขน

7. การหมุนข้อไหล่เข้าและออก

8. การยกแขนขึ้นลงจากด้านข้างไปไหล่ด้านตรงข้าม

9. การยกแขนขึ้นลงจากตะโพกไปไหล่ด้านตรงข้าม



3. แบบบันทึกการฝึกปฏิบัติ

ให้ท่านลงบันทึกทุกครั้งที่ได้ปฏิบัติโปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างมีสติ โดยการบันทึกวันที่ฝึกและทำเครื่องหมาย ‘X’ ในช่องที่ท่านได้ทำการฝึก

	การสแกนร่างกาย	**การนั่งสมาธิ**	**การเคลื่อนไหวอย่างมีสติ**
สัปดาห์1			
ครั้งที่ 1 / 1 วัน_______			
ครั้งที่ 2 / 2 วัน_______			
ครั้งที่ 3 / 3 วัน_______			
สัปดาห์ 2			
ครั้งที่ 4 / 1 วัน_______			
ครั้งที่ 5 / 2 วัน_______			
ครั้งที่ 6 / 3 วัน_______			
สัปดาห์3			
ครั้งที่ 7 / 1 วัน_______			
ครั้งที่ 8 / 2 วัน_______			
ครั้งที่ 9 / 3 วัน_______			

	การสแกนร่างกาย	การนั่งสมาธิ	การเคลื่อนไหวอย่างมีสติ
สัปดาห์4			
ครั้งที่ 10 / 1 วัน_______			
ครั้งที่ 11 / 2 วัน_______			
ครั้งที่ 12 / 3 วัน_______			
สัปดาห์5			
ครั้งที่ 13 / 1 วัน_______			
ครั้งที่ 14 / 2 วัน_______			
ครั้งที่ 15 / 3 วัน_______			
สัปดาห์6			
ครั้งที่ 16 / 1 วัน_______			
ครั้งที่ 17 / 2 วัน_______			
ครั้งที่ 18 / 3 วัน_______			
สัปดาห์7			
ครั้งที่ 19 / 1 วัน_______			

	การสแกนร่างกาย	การนั่งสมาธิ	การเคลื่อนไหวอย่างมีสติ
ครั้งที่ 20 / 2 วัน_______			
ครั้งที่ 21 / 3 วัน_______			
สัปดาห์8			
ครั้งที่ 22 / 1 วัน_______			
ครั้งที่ 23 / 2 วัน_______			
ครั้งที่ 24 / 3 วัน_______			
วัดผลหลังโปรแกรม			

Appendix IX. A logbook of the active control group for Thai older adults.

สมุดคู่มือ

ผลของโปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างมีสติต่อประสิทธิภาพ

การเคลื่อนไหวของรยางค์แขน ในผู้สูงอายุสุขภาพดี โดยการทดลองปกปิดแบบสุ่ม

หลักสูตร 8 สัปดาห์

สารบัญ

1. แผ่นซีดีโปรแกรมการรักษาด้วยการเคลื่อนไหว

ลำดับที่ 1 การสร้างจินตนาการเพื่อการผ่อนคลาย

ลำดับที่ 2 การฟังดนตรีผ่อนคลายเพื่อสมาธิ

ลำดับที่ 3 การออกกำลังกายส่วนของรยางค์แขน

2. โปรแกรมการรักษาด้วยการเคลื่อนไหว

โปรแกรมการรักษาด้วยการเคลื่อนไหว ประกอบด้วย 1) การสร้างจินตนาการเพื่อการผ่อนคลาย 2) การฟังดนตรีผ่อนคลายเพื่อสมาธิ และ 3) การออกกำลังกายส่วนของรยางค์แขน โดยเป็นการฝึกปฏิบัติตามแผ่นซีดี ประมาณ 30 นาทีต่อครั้ง 3 ครั้งต่อสัปดาห์ โดยพยายามให้วันในการฝึกปฏิบัติไม่ติดกัน เช่น วันจันทร์ วันพุธ วันศุกร์ เป็นเวลา 8 สัปดาห์ หลังจากนั้นกลับมาวัดผลหลังโปรแกรมครั้งที่ 1 และฝึกต่อเนื่องไปอีก 8 สัปดาห์ และกลับมาวัดผลหลังโปรแกรมครั้งที่ 2

โดยท่านต้องวางแผนในการฝึกปฏิบัติโปรแกรมการรักษาด้วยการเคลื่อนไหวอย่างสม่ำเสมอ โดยเลือกสถานที่ที่ท่านรู้สึกสะดวกสบาย ปลอดภัยและเป็นช่วงเวลาที่ไม่ถูกรบกวนจากสมาชิกในครอบครัว สัตว์เลี้ยงหรือโทรศัพท์ ขณะปฏิบัติพยายามใส่เสื้อผ้าที่หลวมและสบาย ไม่รัดหน้าท้องหรือหน้าอกจนจำกัดการหายใจ

2.1 การสร้างจินตนาการเพื่อการผ่อนคลาย

การใช้จินตนาการ เป็นวิธีการอย่างหนึ่งที่จะช่วยให้จิตใจของท่านผ่อนคลายละวางจากความตึงเครียดได้ โดยในขณะจินตนาการ ท่านต้องพยายามจินตนาการให้เสมือนจริงที่สุด เพื่อได้สัมผัสครบทั้งภาพ กลิ่น เสียง และสัมผัส เพื่อจะได้เกิดอารมณ์คล้อยตามจนรู้สึกสุขสงบได้เหมือนอยู่ในสถานการณ์นั้นจริง ๆ

ท่าเริ่มต้นในการสร้างจินตนาการเพื่อการผ่อนคลาย

นอนหงายหมอนรองใต้เข่า จัดตัวเองให้อยู่ในท่าที่สบาย ผ่อนคลาย ปลายเท้าแยกจากกันเล็กน้อย วางมือทั้งสองไว้ข้างลำตัว หงายฝ่ามือขึ้น ปล่อยให้มืออยู่ในลักษณะกึ่งกำกึ่งเหยียด ในท่าที่สบาย (รูปที่ 1) เมื่อท่านพร้อมแล้ว ให้เปิดซีดีลำดับที่ 1 ปฏิบัติการสร้างจินตนาการเพื่อการผ่อนคลาย เป็นเวลา 10 นาที

รูปที่ 1 ท่าเริ่มต้นในการสร้างจินตนาการเพื่อการผ่อนคลาย

2.2 การฟังดนตรีผ่อนคลายเพื่อสมาธิ

ดนตรีไม่ใช่แค่เพียงทำให้รู้สึกผ่อนคลายและอารมณ์ดีเท่านั้น แต่ดนตรียังสามารถสร้างสมาธิได้เช่นกันดนตรีคลาสสิคที่ให้คลื่นเสียงอัลฟ่าแก่สมอง คลื่นเสียงจะมีพลังกระตุ้นต่อสมองบางส่วนและระบบประสาทอัตโนมัต ทำให้เกิดการปรับคลื่นสมองเข้าสู่คลื่นอัลฟ่า สร้างความสงบ เกิดการผ่อนคลาย ลดความเครียด ความซึมเศร้า และทำให้เกิดการพัฒนาสมาธิ

ท่าเริ่มต้นในการฟังดนตรีผ่อนคลายเพื่อสมาธิ

นอนหงายหมอนรองใต้เข่า จัดตัวเองให้อยู่ในท่าที่สบาย ผ่อนคลาย (รูปที่ 2) เมื่อท่านพร้อมแล้วก็ให้เปิดซีดีลำดับที่ 2 ปฏิบัติการฟังดนตรีผ่อนคลายเพื่อสมาธิ เป็นเวลา 10 นาที

รูปที่ 2 ท่าเริ่มต้นในการฟังดนตรีผ่อนคลายเพื่อสมาธิ

2.3 การออกกำลังกายส่วนของรยางค์แขน

การออกกำลังกายในส่วนนี้คือการแกว่งแขน เป็นกิจกรรมทางกายอย่างง่ายที่เหมาะสมกับทุกเพศทุกวัย เพราะเป็นการออกกำลังกายที่ง่าย ทำได้ทุกเวลาที่ต้องการ แต่ต้องมีการปฏิบัติอย่างถูกวิธีจึงจะได้ประโยชน์และไม่ก่อให้เกิดอันตรายหรือการบาดเจ็บ จากการวิจัย พบว่า การแกว่งแขนสามารถเผาผลาญได้ถึง 230 แคลอรี่ต่อชั่วโมง ซึ่งใกล้เคียงกับเดิน และไม่เกิดผลเสียใดๆ ทั้งระยะสั้นและระยะยาว โดยเมื่อท่านแกว่งแขนไปข้างหน้าจะรู้สึกลำตัวเซไปข้างหน้าเล็กน้อยใช้ฝ่าเท้ารับน้ำหนัก ถ่ายน้ำหนักไปที่ปลายเท้าเพื่อสร้างสมดุลกับลำตัวที่เซไปข้างหน้า เมื่อแกว่งไปข้างหลังก็ถ่ายน้ำหนักมาที่ส้นเท้าเพื่อสมดุลกับน้ำหนักลำตัวที่เซไปข้างหลัง ซึ่งการเซไปข้างหน้าและข้างหลังนั้นเป็นผลจากการแกว่งแขน ซึ่งทำให้ท่านได้ออกกำลังโดยใช้กล้ามเนื้อมัดใหญ่ด้านล่างถึง 12 มัด เช่น กล้ามเนื้อสะโพก กล้ามเนื้อต้นข้าด้านหน้าและด้านหลัง กล้ามเนื้อส่วนน่องด้านสันหน้าแข้งและน่องด้านหลัง กล้ามเนื้อที่ฝ่าเท้า ดังนั้นการแกว่งแขนจะเหมือนกับการออกกำลังกายโดยการเดิน เพียงแต่การเดินร่างกายมีการเคลื่อนที่ไปข้างหน้าแกว่งแขนสลับซ้ายขวา ส่วนการแกว่งแขนนั้นร่างกายอยู่กับที่แกว่งแขนซ้ายและขวาไปข้างหน้าและข้างหลังพร้อมกัน

วิธีการออกกำลังกายโดยการแกว่งแขน

- ☐ ยืนตัวตรง เข่าไม่งอ แยกเท้าทั้งสองข้างออกจากกัน โดยมีระยะห่างประมาณความกว้างหัวไหล่
- ☐ ปล่อยมือทั้งสองข้างลงตามธรรมชาติ ไม่เกร็ง ให้นิ้วมือชิดกัน หันอุ้งมือไปข้างหลัง
- ☐ เขม่วท้องน้อยเข้า เอวตั้งตรง เหยียดหลัง ผ่อนคลายคอ ศีรษะ และปาก
- ☐ จิกปลายนิ้วเท้ายึดเกาะพื้น ส้นเท้าออกแรงเหยียบลงบนพื้นให้แน่น
- ☐ ขณะออกกำลังกายโดยการแกว่งแขนต้องหดก้นหรือขมิบทวารหนัก
- ☐ ตามองตรงไปจุดใดจุดหนึ่ง ปล่อยวางความคิด ความกังวล นำความรู้สึกตัวมาอยู่ที่เท้า
- ☐ แกว่งแขนไปข้างหน้าเบาๆ ทำมุม 30 องศากับลำตัว หายใจเข้า แล้วแกว่งไปข้างหลังเพิ่มความแรงขึ้นเล็กน้อย ทำมุม 60 องศากับลำตัว จะทำให้เกิดแรงเหวี่ยง หายใจออกขณะแกว่งไปข้างหลัง โดยปล่อยน้ำหนักมือให้เหมือนลูกตุ้ม และต้องสะบัดมือทุกครั้ง เพื่อให้เลือดหมุนเวียนไปถึงปลายนิ้ว

เมื่อท่านพร้อมแล้วก็ให้เปิดซีดีลำดับที่ 3 ปฏิบัติการออกกำลังกายส่วนของรยางค์แขน เป็นเวลา 10 นาที

3. แบบบันทึกการฝึกปฏิบัติ

ให้ท่านลงบันทึกทุกครั้งที่ได้ปฏิบัติโปรแกรมการรักษาด้วยการเคลื่อนไหว โดยการบันทึกวันที่ฝึกและทำเครื่องหมาย ‘X’ ในช่องที่ท่านได้ทำการฝึก

	จินตนาการเพื่อการผ่อนคลาย	ฟังดนตรีผ่อนคลายเพื่อสมาธิ	ออกกำลังกายส่วนของแขน
สัปดาห์1			
ครั้งที่ 1 / 1 วัน_______			
ครั้งที่ 2 / 2 วัน_______			
ครั้งที่ 3 / 3 วัน_______			
สัปดาห์ 2			
ครั้งที่ 4 / 1 วัน_______			
ครั้งที่ 5 / 2 วัน_______			
ครั้งที่6 / 3 วัน_______			
สัปดาห์3			
ครั้งที่ 7 / 1 วัน_______			
ครั้งที่ 8 / 2 วัน_______			
ครั้งที่ 9 / 3 วัน_______			
สัปดาห์4			
ครั้งที่ 10 / 1 วัน_______			

	จินตนาการเพื่อการผ่อนคลาย	ฟังดนตรีผ่อนคลายเพื่อสมาธิ	ออกกำลังกายส่วนของแขน
ครั้งที่ 11 / 2 วัน_______			
ครั้งที่ 12 / 3 วัน_______			
สัปดาห์5			
ครั้งที่ 13 / 1 วัน_______			
ครั้งที่ 14 / 2 วัน_______			
ครั้งที่ 15 / 3 วัน_______			
สัปดาห์6			
ครั้งที่ 16 / 1 วัน_______			
ครั้งที่ 17 / 2 วัน_______			
ครั้งที่ 18 / 3 วัน_______			
สัปดาห์7			
ครั้งที่ 19 / 1 วัน_______			
ครั้งที่ 20 / 2 วัน_______			
ครั้งที่ 21 / 3 วัน_______			
สัปดาห์8			
ครั้งที่ 22 / 1 วัน_______			

	จินตนาการเพื่อการผ่อนคลาย	ฟังดนตรีผ่อนคลายเพื่อสมาธิ	ออกกำลังกายส่วนของแขน
ครั้งที่ 23 / 2 วัน_______			
ครั้งที่ 24 / 3 วัน_______			
วัดผลหลังโปรแกรม			

Appendix X. Research Ethics Committee number.

Effective date: 1 Jan 2017 AL-011_ENG

FACULTY OF MEDICINE
PRINCE OF SONGKLA UNIVERSITY

Human Research Ethics Committee

Faculty of Medicine, Prince of Songkla University

This document is a record of review and approval/acceptance of clinical study protocol.

REC:	60-135-30-2
Protocol Title:	The Effect of Mindfulness Movement Therapy Programme on Arm and Hand Function in Patients with Stroke: A Preliminary Study
Principal Investigator:	Mr.Weeranan Yaemrattanakul
Affiliation:	Department of Physical Therapy Faculty of Medicine, Prince of Songkla University
Co-investigator:	Sittipong Tipchatyotin, M.D.
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Approved documents:

1. Submission form version 3.0 date July 24, 2017
2. Study protocol version 3.0 date July 24, 2017
3. Information sheet and consent form version 3.0 date July 24, 2017
4. Clinical record form
5. Curriculum Vitae

Human Research Ethics Committee
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