# Mindfulness, Sleep Quality, and Objective and Subjective Cognitive Function in Healthy Older Adults

**Colm Lannon-Boran**

**BA (Honours) Psychology**

*Thesis submitted to the Maynooth University Department of Psychology, in fulfilment of the requirements for the joint degree of Master of Science (MSc) by Research, Maynooth University & National College of Ireland*

**December 2025**

**Head of Department: Prof. Deirdre Desmond**

**Supervisors: Dr Michelle Kelly, Dr Joanna McHugh Power, & Dr Caoimhe Hannigan**

# Table of Contents

# Acknowledgements

Firstly, I would like to thank my supervisors, Dr Michelle Kelly, Dr Joanna McHugh Power, and Dr Caoimhe Hannigan for their assistance, understanding, and of course, expert guidance and feedback throughout this project. I have learned so much from your expertise and knowledge, and I feel genuinely privileged to have worked with such accomplished researchers. Michelle, as my primary supervisor, consistently went above and beyond to offer support, encouragement, and constructive advice at every stage and for that I am incredibly grateful.

I would also like to extend heartfelt thanks to my friends and colleagues for their camaraderie and encouragement, particularly during the early stages of this journey. Grainne, Brian, and Hannah, the shared brainstorming sessions, conversations, and laughter, whether online or in person, helped sustain and energise me through the most demanding periods. To my wider circle of friends and colleagues who checked in and celebrated milestones with me along the way, your kindness did not go unnoticed.

I have to acknowledge the unconditional love and support of my family. My parents, Eithne and Bernard, have always been there to motivate and ground me, and this accomplishment would not have been possible without them. To my partner in life, Chantal, words alone cannot fully express my gratitude and appreciation. Your patience, understanding, and unwavering support kept me going throughout this process, and this thesis certainly would not have been finished without you. Last but not least, and as part of my family, I must thank two cats, Penny and Wilbur, for their (mostly) constant emotional support. They were always there to remind me what true mindfulness looked like, and thus never failed to bring me a sense of peace and comfort.

# List of Figures

## Chapter 1

## Chapter 2

## Chapter 3

# List of Tables

## Chapter 3

# List of Abbreviations

| | |
|---|---|
| **ACC** | Anterior Cingulate Cortex |
| **AD** | Alzheimer’s Disease |
| **APA** | American Psychological Association |
| **CDS** | Cognitive Difficulties Scale (McNair) |
| **CBT** | Cognitive Behavioural Therapy |
| **CR** | Cognitive Reserve |
| **DMN** | Default Mode Network |
| **EEG** | Electroencephalography |
| **FAM** | Focused Attention Meditation |
| **FFMQ** | Five Facet Mindfulness Questionnaire |
| **fMRI** | Functional Magnetic Resonance Imaging |
| **GABA** | Gamma-aminobutyric Acid |
| **MAT** | Monitor and Acceptance Theory |
| **MBCT** | Mindfulness-Based Cognitive Therapy |
| **MBI** | Mindfulness-Based Intervention |
| **MBSR** | Mindfulness-Based Stress Reduction |
| **MCI** | Mild Cognitive Impairment |
| **MDRS** | Mattis Dementia Rating Scale |
| **MMSE** | Mini-Mental State Examination |
| **nREM** | Non-Rapid Eye Movement |
| **NTs** | Neurofibrillary Tangles |
| **OMM** | Open Monitoring Meditation |
| **PACC** | Preclinical Alzheimer Cognitive Composite |

|  |  |
|---|---|
| **PRISMA** | Preferred Reporting Items for Systematic Reviews and Meta-Analyses |
| **PSQI** | Pittsburgh Sleep Quality Index |
| **RCT** | Randomized Controlled Trial |
| **REM** | Rapid Eye Movement |
| **SCD** | Subjective Cognitive Decline |
| **SCF** | Subjective Cognitive Function |
| **SD** | Standard Deviation |
| **SWS** | Slow Wave Sleep |
| **TBI** | Traumatic Brain Injury |
| **WASO** | Wake After Sleep Onset |
| **WHO** | World Health Organization |

# Abstract

*Objective*: Global increases in age means it is important to examine interventions and factors that can address age-related cognitive decline and its associated risk of dementia before cognitive impairment develops. This thesis aimed to investigate the relationship between mindfulness and subjective and objective cognitive function, as well as sleep quality and its role in the relationship between mindfulness and these outcomes, in healthy older adults. *Method*: Chapter 2 (Ch2) was a systematic review and meta-analysis of seven randomized-controlled trials (RCT) investigating mindfulness-based intervention's (MBI) effect on objective cognitive function and sleep quality in healthy older adults. Chapter 3 (Ch3) was a secondary analysis of RCT data (SCD-Well trial) examining trait mindfulness, MBI, subjective cognitive function (SCF), and sleep quality as a mediator between MBI and SCF in healthy older adults with subjective cognitive decline (SCD). *Results*: Meta-analysis revealed no significant effect of MBI on objective cognitive function but demonstrated significant improvements in sleep quality in healthy older adults with non-clinical sleep difficulties. Ch3 regression analysis showed trait mindfulness was significantly associated with SCF. Repeated measures ANOVA found a significant effect of time on SCF, with no significant group difference. Mediation analysis showed sleep quality did not mediate the MBI-SCF relationship; baseline SCF significantly predicted follow-up sleep quality and follow-up SCF, and trait mindfulness significantly predicted follow-up SCF. *Conclusion*: MBI improves sleep problems in healthy older adults but is not more effective than active controls for objective cognitive outcomes. Although trait mindfulness is associated with better SCF, MBI is not superior to psychoeducation for improving SCF. Mediation results suggests the directionality of the sleep-SCF relationship may be more complex than hypothesised.

Limitations include few eligible RCTs, incomplete RCT data access, and measurement heterogeneity (Ch2), potential ceiling effects in sleep (Ch3) and cognition (Ch2), and possible personality trait confounds. Findings have implications for early, longer duration MBIs to promote trait mindfulness and sleep quality in healthy older adults. Future research should investigate mindfulness and psychological, neural, or cognitive reserve outcomes rather than objective cognitive function in healthy older adults.

# Chapter 1: Literature Review

## 1.1 Introduction

Life expectancy has nearly doubled in the twentieth century (Schaie, 2021; World Health Organization [WHO], 2020), with many countries' populations now classed as "ageing societies", including the U.S, many nations across Western Europe, and parts of Asia. This list continues to expand as the global population of older adults grows at an unprecedented rate. In 2020, the population of people over 60 worldwide was just over 1 billion, up from 700 million in 2007 (Daffner, 2010; Department of Economic and Social Affairs PD, 2007) and is projected to more than double to 2.1 billion by 2050 (WHO, 2020). Of these 1 billion people aged over 60, it is conservatively estimated that 50 million suffer from dementia, a number projected to reach 82 million by 2030, and then triple to 152 million by 2050 (Patterson, 2018). This rapid increase in the ageing population has resulted in increasing numbers of people experiencing age-related cognitive decline, which can be either non-pathological (often referred to as "normal", "healthy", or "unimpaired") or pathological (dementia or disease-related and impairing) (Livingston et al., 2024). Non-pathological age-related cognitive change is generally considered a normal part of the ageing process – albeit with great interindividual variability – whereupon decline can be experienced across a range of cognitive domains such as memory, attention, processing speed, executive function, and subjective cognitive function (SCF) (Mahendran et al., 2015). Such decline is subtle and has minimal impact on everyday functioning and quality of life (Salthouse, 2012). It is important to understand lifestyle factors and interventions that can potentially ameliorate this projected increase in age-related cognitive decline, and the subsequent increased risk of diseases for which there are currently no cures (WHO, 2020). The WHO (2015) have stated “life choices or interventions at different points during the life course will determine the path or trajectory of each individual” (p. 13), highlighting this need on a global level. It is therefore worth outlining distinct stages of cognitive ageing when considering intervention timing.

Healthy older adults progress to dementia at an annual rate of 1%–2%, compared to a 10%–15% rate in older adults with mild cognitive impairment (MCI) (Rusinek et al., 2003). Due to these rates of progression and the presence of dementia-related neuropathology, MCI is thought to be a transitional predementia phase between non-pathological age-related cognitive decline and dementia (Albert, 2011). Reducing risk of age-related cognitive decline developing to MCI, or maintaining cognitive function as one enters later life, could reduce risk of the onset of pathological decline and reduce the number of future dementia cases (Barnes & Yaffe, 2011). A quarter of healthy older adults who develop MCI are individuals with subjective cognitive decline (SCD), the criteria for which are a self-reported decline in cognitive abilities in the last 6 months (on SCF measures), and performance within normal ranges on objective cognitive measures (Jessen et al., 2020). Those with SCD are at approximately doubled risk of progressing to dementia compared to those without SCD (Mitchell et al., 2014). That said, despite clear elevated risk with age (Reuter-Lorenz et al., 2021), and further elevated risk with SCD (Slot et al., 2019), the majority of older adults with SCD will not develop MCI or dementia (Harada et al., 2013). So, not only is it important to consider overall dementia risk in SCD, but also to understand the characteristics associated with positive cognitive outcomes in SCD. This may provide insight into factors that promote successful cognitive ageing and/or reduce dementia-risk at an early stage.

Dementia is an umbrella term that refers to a collection of major neurocognitive disorders characterised by difficulties with memory, language, attention, and executive functions, to such an extent that the individual's ability to perform everyday tasks is severely reduced (American Psychological Association [APA], 2021). Neither MCI nor SCD classify as dementia due to absence of these symptoms or severe daily-functioning declines (Petersen et al., 2014; Reisberg et al., 2008). Onset of dementia and speed of progression is influenced by age, genetics, biological sex, sleep quality, lifestyle factors associated with cognitive reserve, and other modifiable risk factors such as depression, hypertension, smoking and excessive alcohol consumption, social contact, physical activity, and traumatic brain injury (Livingston et al., 2024). The most common cause of dementia is Alzheimer's disease (AD), which accounts for 60-80% of dementia cases worldwide (WHO, 2020). In AD, areas of the brain associated with executive function and memory deteriorate and are damaged by clumps of malformed beta-amyloid proteins (plaques), which occur outside of neurons, and malformed strands of the protein tau inside neurons (neurofibrillary tangles) (Yochim & Mast, 2021). The default mode network of the brain (DMN), a network involved in internally-oriented process such as self-reflection, mind-wandering, autobiographical memory retrieval, envisioning the future, and understandings others' mental states (Yeshurun et al., 2021), is where these pathological aggregations tend to accumulate in the lead up to AD (Katsumi et al., 2024; Palmqvist et al., 2017). These neurostructural changes are present and considered to have reached a pathological stage in MCI (Petersen, 2004). They are more subtly present in SCD, where they are not yet considered pathological (Rivas-Fernández et al., 2023).

When cognitive changes cause mild problems with everyday functioning but do not reach the threshold for dementia diagnosis, individuals may be diagnosed with MCI, which is associated with increased risk of dementia (Albert, 2011). In recent years, the cognitive status of SCD has received increasing attention as a non-pathological stage that precedes MCI (Cappa et al., 2024). MCI is not considered normal in the ageing process and is often described as a prodromal predementia phase of AD, while SCD is considered normal or cognitively unimpaired based on performance on objective cognitive tests (Jessen et al., 2014; Reisberg et al., 2010). SCD is still associated with increased risk of future impairment and progression to MCI, and then dementia, most prominently AD (Reisberg et al., 2010; Slot et al., 2019). As individuals with SCD have unimpaired objective cognitive function, this diagnostic group have been identified as a priority for accessing non-pharmacological interventions (e.g., psychoeducation, social engagement, physical activity, mindfulness training) that may allow brain health and cognitive ability to be preserved (Munro et al., 2023; Yingmei et al., 2025). Appropriate non-pharmacological interventions in SCD may reduce cognitive decline progression and future dementia rates (Espinoza Jeraldo et al., 2024; Munro et al., 2023). Further, a wealth of literature has focused on understanding factors that may promote cognitive function in ageing in healthy older adults, aiming to mitigate or prevent pathological characteristics of dementia developing. These factors include physical exercise (Ahlskog et al., 2011; Blondell et al., 2014), mental and cognitive stimulation (Aguirre et al., 2013), social engagement (Kelly et al., 2017; Sommerlad et al., 2023), mindfulness (Luders et al., 2016; Whitfield, Barnhofer, Acabchuk, et al., 2022) , and sleep quality (McCall & Watson, 2021).

## 1.2 Cognitive Function in Ageing

Cognitive function encompasses a range of distinct but intercorrelated cognitive abilities or domains (Tucker-Drob, 2019). These domains are conceptualised in various ways; fluid reasoning (ability to efficiently solve abstract problems), processing speed (speed of carrying out mental tasks), visuospatial ability (ability to mentally manipulate objects), working or short-term memory (holding information in consciousness and manipulating it), declarative memory (conscious recollection of facts and events), nondeclarative memory (unconscious motor and cognitive skills, learned procedures), language, crystallized knowledge (ability to recite and apply cultural information), and executive functions (processes that regulate the ability to plan, make decisions, problem-solve, organise, and be mentally flexible) (Harada et al., 2013; Tucker-Drob, 2019). Overall cognitive ability is dictated by interactions between these domains, but not all domains are similarly affected by age (Reuter-Lorenz et al., 2021). Nevertheless, certain trends or patterns are apparent in how these domains generally change as age increases, and these trends differ between normal, non-pathological age-related decline and pathological decline (Gonzales et al., 2022).

In healthy ageing, it is considered normal to experience declines in processing speed (Zimmerman & Brickman, 2009), resulting in poorer performance on a variety of neuropsychological measures (Harada et al., 2013), which strongly predict real-world outcomes (Tucker-Drob, 2019). Working memory and episodic memory also decline in healthy ageing, but semantic memory, recognition memory and procedural memory remain relatively spared (Harada et al., 2013; Rönnlund et al., 2005). Declines in memory may be related to reductions in processing speed (Luszcz & Bryan, 1999) and a decline in the executive ability to inhibit distractions disrupting attention (Darowski et al., 2008). Executive functions plays a complex role in cognitive ageing, a role not yet fully understood (Reuter-Lorenz et al., 2021). Various executive functions decline with age, especially those requiring good processing speed (Hayden et al., 2012) while others remain stable. Research suggests that executive functions such as concept formation, abstraction, mental flexibility, response inhibition, inductive reasoning – especially reasoning with unfamiliar material – decline with age, albeit these declines vary between individuals (Singh-Manoux et al., 2012; Wecker et al., 2000). Despite this heterogeneity, it is evident that executive functions are crucial to maintaining healthy cognitive function as age increases (Reuter-Lorenz et al., 2021).

Language is a cognitive ability that, overall, remains intact in healthy ageing. Some studies show vocabulary improves with age (Hayden & Welsh-Bohmer, 2012; Salthouse, 2009; Singh-Manoux et al., 2012), while another study found evidence that the ability to name a common object remains stable until 70 years of age and then begins to decline (Zec et al., 2005). The verbal fluency aspect of language tends to decline with age (Salthouse, 2004). Visuospatial abilities such as object and spatial perception tend to remain intact in healthy ageing (Harada et al., 2013), although the ability to construct pieces together to make a coherent whole declines (Howieson et al., 1993). Higher scores on standardised tests of these aforementioned domains of cognitive function is associated with protection against pathological cognitive decline, potentially from heightened levels of cognitive reserve (Hannigan et al., 2013). Cognitive reserve is a theory which postulates that some individuals have a compensatory reservoir (or reserve) of extra cognitive capacity that is recruited when other domains of cognitive function decline (Stern, 2020). This offers an explanation as to why cognitively healthy older adults seem to lean more heavily on executive functions to undertake cognitive tasks previously dictated by different domains (Cabeza et al., 2018; Reuter-Lorenz & Cappell, 2008).

Another useful categorization system for describing how cognitive abilities change over the lifespan is that of crystallized vs fluid ability (Cattell, 1963). Crystallized abilities refer to an individual's general knowledge, vocabulary, and reasoning skills that have been consolidated from personal experiences over the lifespan, and thus older adults tend to perform better than younger adults on tasks involving crystallized abilities (Kaufman & Horn, 1996). Fluid abilities, on the other hand, refer to cognitive abilities of reasoning and problem-solving for which solutions are novel or unfamiliar (Shakeel & Goghari, 2017). Processing speed, memory, and executive functions are considered fluid cognitive domains (Rog & Fink, 2013). Fluid ability also concerns one's innate ability to learn new information (Deary et al., 2009; Horn & Hofer, 1992). Openness to experience is associated with better fluid abilities in middle-aged and older adults (Silvia & Sanders, 2010; Zimprich et al., 2009). Interestingly, a key element of mindfulness involves practicing open-minded curiosity (Kabat-Zinn, 2013), and links have been made between mindfulness, fluid cognitive abilities, cognitive reserve, executive function, and global cognitive function (Barkan et al., 2016; Gard, Hölzel, et al., 2014; Tang & Braver, 2020).

## 1.3 Mindfulness and Older Adults' Cognitive Function

### *1.3.1 Defining Mindfulness in the Current Context*

Mindfulness refers to awareness of present moment experience, and the ability to observe the content of present moment experience non-judgmentally, curiously, and with open-mindedness (Kabat-Zinn, 2013). Mindfulness can be practiced through meditation, or “state” mindfulness, which involves purposely entering a state of present moment awareness, often through means of attending to the breath, the body, or something external for a select period of time. Meditation is also about cultivating a curious, open, and compassionate attitude (Creswell, 2017). Openness and acceptance towards the content of present moment experience are a critical component of mindfulness practice; inviting all experience to rest in full awareness without judgment. Intentional awareness of present-moment experience with these attitudinal elements is synonymous with state mindfulness. State mindfulness can also be practiced informally outside of planned meditation periods, which is encouraged in standardised mindfulness-based intervention (MBI) protocols and is often a biproduct of increased formal meditation time (Creswell, 2017).

Trait or dispositional mindfulness, on the other hand, refers to an individual’s innate tendency to be aware of and attend to present moment experience nonjudgmentally (Brown & Ryan, 2003). Possessing higher levels of trait mindfulness can make it easier for individuals to practice and benefit from meditation (Kiken et al., 2015; Tang et al., 2016). As there is a specific attitudinal element to mindfulness, it is unsurprising that research has shown trait mindfulness to be significantly associated with each Big Five personality trait (Hanley, 2016); individual personality differences can affect ability to practice and benefit from meditation. A systematic review conducted by Park et al. (2013) analysed ten existing mindfulness measures, concluding a lack of evidence supporting validity, although the Five Facet Mindfulness Questionnaire (FFMQ) (Baer et al., 2006) received the highest rating for internal consistency and construct validation. Park’s review was a catalyst for the growing body of research investigating the neural underpinnings of mindfulness, including research by Tang et al. (2016) and Wheeler et al. (2016). These papers have led to greater consensus that 1) state mindfulness relates to temporary changes to the state of brain activity and connectivity, and 2) that practicing this state can alter mindfulness-related personality traits such as openness, curiosity, acceptance, and nonjudgment (trait mindfulness); this is what the FFMQ captures better compared to other measures.

Researchers have investigated the DMN in the brain in relation to mindfulness, a network associated with our “default-mode” of attending to experience (Andrews-Hanna et al., 2014). Increased activity in the DMN is associated with spontaneous, but not deliberate, mind-wandering and introspective thinking (Raichle, 2015; Sorella et al., 2025). This brain network should be affected by mindfulness if practicing mindfulness alters our default method of attending to experience. Meditation has indeed been shown to alter DMN function (Creswell et al., 2016). Those high in trait mindfulness may also be able to selectively switch attention to present moment experience, i.e., regulate activity in the DMN, more efficiently (Fountain-Zaragoza et al., 2016). Further neuroscientific trial investigations show improved connectivity and regulation in the DMN (and other major brain networks) from state mindfulness practice, associated with reductions in rumination and mind-wandering (Bremer et al., 2022; Rahrig et al., 2022). That said, some reviews suggest that consistent and specific conclusions on the impact of different types of mindfulness practices on the DMN’s function and structure are difficult to ascertain due to heterogeneity across studies (Fox et al., 2016; Fox et al., 2014). However, it has been ascertained in meta-analysis that one of the most basic and introductory forms of mindfulness practice, focused attention meditation (FAM), which is included in standardised MBI protocols, is consistently associated with DMN activity regulation (Ganesan et al., 2022).

From a cognitive perspective, two broad categories or types of state mindfulness practice have been proposed; open monitoring meditation (OMM), which refers to resting awareness broadly on all present stimuli, and seems to parallel the cognitive process of divided attention, and FAM, which involves narrowing the scope of awareness to attend to one focal stimulus, and reflects the cognitive process of selective attention (Cahn & Polich, 2006; Lutz et al., 2008). For example, a sitting meditation where one rests their awareness on the breath would fall under FAM, as only one object – the breath – is being (selectively) attended to. What separates meditation from a general form of attentional or cognitive training is the goal of the practice; the goal of meditation is not to improve attention (although this may be a welcome effect) but to cultivate trait mindfulness, i.e., to practice curious, nonjudgmental awareness of experience, no matter the content of experience (Kabat-Zinn, 2013). Evidence suggests consistently practicing mindfulness informally (during everyday tasks) and formally (meditation) within MBIs leads to an increase in trait mindfulness (Kiken et al., 2015). FAM is the technique largely implemented when first learning how to practice mindfulness in MBI, as it is a more basic and familiar process to attend to one thing than is it to openly monitor many stimuli without focusing attention on a single stimulus (Vago & Silbersweig, 2012). This distinction in types of meditation is supported by neuroimaging research showing consistently differentiating DMN activity patterns when comparing brains in a state of FAM and brains in a state of OMM (Marzetti et al., 2014). This has implications when utilising MBI for the purpose of improving or maintaining cognitive functions in older adults and possibly targeting different cognitive domains. Although cognitive and neural processes are distinct across FAM and OMM (Marzetti et al., 2014), both still aim to strengthen two underlying core mechanisms: attention monitoring (awareness) and acceptance of present-moment experience.

The presiding theoretical framework pertaining to mechanisms of action in mindfulness is Monitor and Acceptance theory (MAT) (Lindsay & Creswell, 2017). MAT proposes that mindfulness works through the two core skills of monitoring present-moment experience (i.e., awareness), and acceptance of the content of present-moment experience, which have distinct and synergistic effects on cognitive function, emotion, stress, and health outcomes (Lindsay & Creswell, 2019). Monitoring training alone may improve cognitive performance in relatively neutral contexts (e.g., enhancing attention in controlled cognitive tests), but by increasing awareness of experiences, it may also intensify affective reactivity if the ability to accept present-moment experience is absent. Well controlled RCTs have demonstrated that combining training in monitoring and acceptance is superior to control groups practicing monitoring only, and no-treatment controls, for improving stress and positive affect (Chin et al., 2019; Lindsay et al., 2018). MAT also posits that, for objective cognitive outcomes that are “affectively neutral”, monitoring training alone may be sufficient. For subjective cognitive outcomes which encompass individuals’ concerns and worries about the severity of their perceived cognitive decline, both attention monitoring and acceptance training are likely necessary for impact (Lindsay & Creswell, 2019). Standardised MBIs such as Mindfulness-based Stress Reduction (MBSR) and Mindfulness-based Cognitive Therapy (MBCT) include a focus on these two core skills.

### ***1.3.2 Mindfulness-based Intervention***

MBIs are the result of the western world’s efforts to apply science and systematic method to meditation practices rooted in eastern Buddhism. Although mindfulness is not exclusively derived from Buddhism, present-day secular MBIs have been heavily influenced by millennia of Buddhist tradition and scholarship (Anālayo, 2019). MBI can be defined as an intervention that trains the individual in cultivating nonjudgmental present moment awareness through systematic engagement in various meditation techniques (Goldberg, 2022). The most empirically researched MBIs are MBSR (Kabat-Zinn, 2013), an 8-week mindfulness intervention originally created to reduce stress and chronic pain, and MBCT (Segal et al., 2018), which was adapted from MBSR and cognitive behavioural therapy (CBT) to focus on treating depression (Goldberg et al., 2022). There are some well-developed, standardised MBIs focused on substance-abuse as well: Mindfulness-based Relapse Prevention (Bowen et al., 2021), Mindfulness Training for Smokers (Brewer et al., 2011), Mindfulness-Oriented Recovery Enhancement (Garland, 2024).

The majority of MBIs are based on MBSR protocol (Goldberg et al., 2022). Participants are taught various meditation techniques, beginning with FAM techniques such as sitting meditation and body scan, which enable entering a state of mindfulness. Other techniques taught are mindful movement and hatha yoga, a gentle series of stretching poses that can be done seated if necessary (Kabat-Zinn, 2013). FAM is particularly rooted in Zen meditation, a form of Buddhist meditation that originated in China and emphasizes cultivating mindfulness through sitting in silent stillness and focusing on breath and posture (Marciniak et al., 2014). OMM and body scanning are derived from Vipassana techniques from Theravada Buddhism, one of the oldest schools of Buddhism, which emphases individual liberation and development of wisdom through direct experience of reality (Al-Hussaini et al., 2001). MBSR also borrows from metta meditation, which aims to cultivate feelings of goodwill, kindness, and compassion towards oneself and others (Amihai & Kozhevnikov, 2015). MBSR further includes one all-day mindfulness retreat, where participants are introduced to a broader array of meditation techniques, some of which are more advanced (such as OMM and prolonged body scans) and participate in long periods of silent meditation. During the 8-weeks, participants are asked to meditate every day outside of the one 2.5 hour weekly class. As the course progresses, participants are encouraged to personalise their home meditation practice and experiment with different techniques learned, to identify which type of meditation is effective for them to achieve a state of mindfulness, although there is emphasis on practicing for 45+ minutes per day (Kabat-Zinn, 2013).

Extant literature on MBIs has explored the effect of systematic mindfulness practice on a variety of psychological conditions, but recently more scrutiny has been placed on mindfulness and cognitive function in older populations. Maintaining brain health and cognitive ability in later life has become a public health priority, and early investigations into mindfulness and brain/cognitive health indicate that MBI may be a viable, cost-effective, and easily accessible option to enhance cognitive functions and maintain brain health in ageing (Fountain-Zaragoza & Prakash, 2017; Gard, Hölzel, et al., 2014). MBI is associated with improved brain health, structure, and function in the areas of the brain (such as the DMN) observed to atrophy in neurodegenerative diseases, particularly AD (Heutz, 2017).

Other work has found MBIs to be effective for reducing stress (Baer et al., 2012; Chiesa & Serretti, 2009; Grossman et al., 2004; Khoury et al., 2015; Sharma & Rush, 2014), hypertension (Conversano et al., 2021), and depression (Segal et al., 2018; Strauss et al., 2014), all of which are modifiable risk-factors of cognitive decline and dementia (Baumgart et al., 2015; Livingston et al., 2024). MBI is useful in treating smoking and alcohol addiction (Brewer et al., 2011; Garland, 2019) – which are also modifiable risk factors for cognitive decline and dementia (Baumgart et al., 2015; Livingston et al., 2024). Literature also suggests that mindfulness is associated with better sleep quality, and in many cases, MBI improves sleep outcomes (Black et al., 2015; Wang et al., 2019; Zhang et al., 2015). Sleep quality is recognised as being involved in preserving brain health and cognitive function in later life (McCall & Watson, 2021). As sleep quality generally becomes poorer with age (Ancoli-Israel & Cooke, 2005; Neikrug & Ancoli-Israel, 2010), improving sleep outcomes in older adults is another area of interest in protecting against cognitive decline and dementia (Livingston et al., 2024).

### *1.3.3. Research on Mindfulness and Cognitive Health*

In recent years, the potential of practicing mindfulness in the context of successful cognitive ageing has garnered interest, with many researchers theorising and proposing that practicing mindfulness contributes to healthy cognitive ageing (Acevedo et al., 2016; Chételat et al., 2018; Fountain-Zaragoza & Prakash, 2017; Lutz et al., 2021; Malinowski & Shalamanova, 2017; Xiong et al., 2009). In MCI, preliminary evidence from a pilot RCT found that MBI improved functional connectivity (i.e., the degree to which distinct brain regions show temporally correlated neural activity) in the DMN of older adults with MCI compared to controls under treatment-as-usual conditions (Wells et al., 2013). The potential of mindfulness to impact dementia progression and to protect against AD (Heutz, 2017) is shown in a two-year RCT that found older adults with mild-moderate AD (treated with donepezil medication across groups) maintained cognitive function better than would be expected for their stage of AD progression (Quintana-Hernández et al., 2016). Notably, the MBI group maintained cognitive function (sense of direction, language, memory, perception, attention, and praxia) better than a progressive muscle relaxation group and an inactive control, and was statistically equivalent to the usual non-pharmacological AD intervention, cognitive stimulation therapy, though the MBI group still showed a trend of greater stability. This may be due to links between mindfulness and brain function and structure that suggest mindfulness has protective effects on regions of the brain implicated in cognitive decline and neurodegenerative disease (Hölzel et al., 2011, Lutz et al., 2021; Vago & Silbersweig, 2012), as was indicated in Wells and colleagues' (2013) and Quintana-Hernandez and colleagues' (2016) trials.

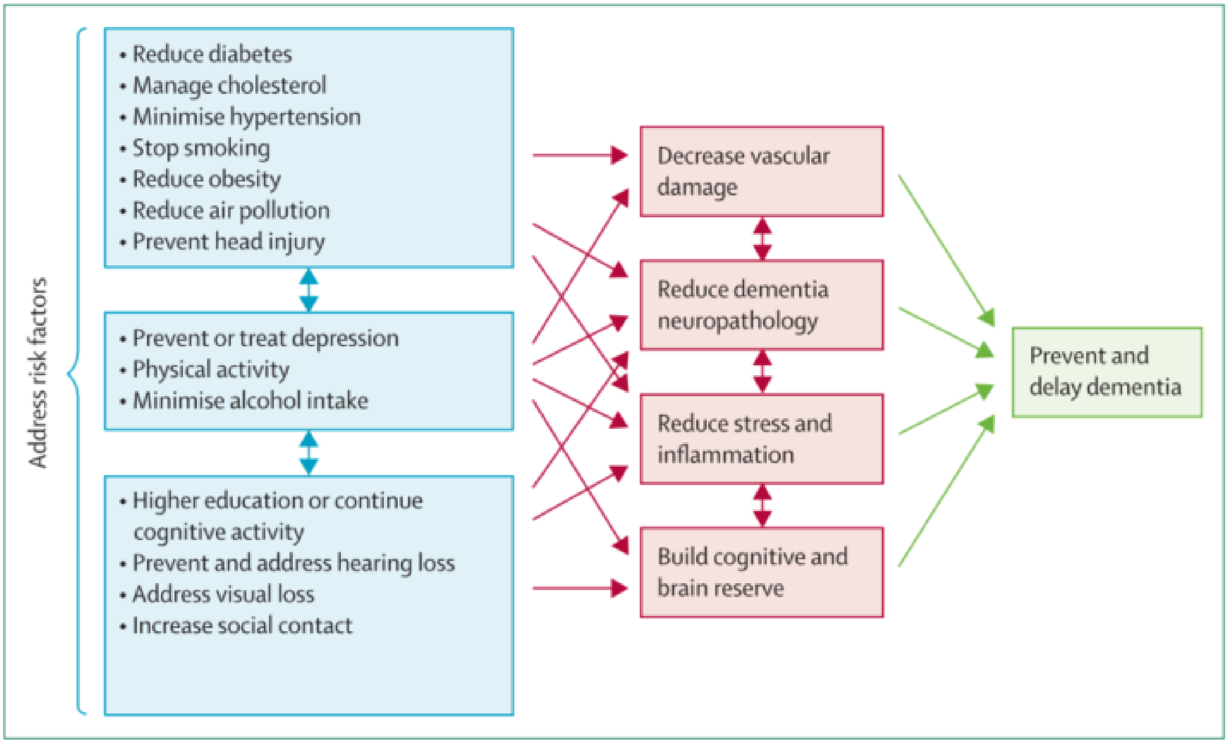
A wealth of research has been conducted on mindfulness and factors associated with cognitive decline and dementia risk, which provides insight into the potential of mindfulness to mitigate cognitive decline risk.

### *1.3.4 Mindfulness and Risk Factors for Cognitive Decline*

Mindfulness has been shown to have a beneficial influence on a number of cognitive decline risk factors that are outlined by Livingston et al. (2024). The possibility that practicing mindfulness has a synergistic effect on cognitive health by effecting multiple risk-factors should be considered, as well as potentially building and maintaining cognitive reserve (CR) (Malinowski & Shalamanova, 2017; Wells et al., 2019). Livingston et al. (2024) identified 14 modifiable risk factors that could protect against cognitive decline (see Figure 1.1), which together account for approximately 45% of dementia cases worldwide (Livingston et al., 2024).

**Figure 1.1**

*Livingston and colleagues' (2024) 14 Risk-factor Model of Dementia Prevention*



*Note.* Figure shows possible mechanisms for enhancing or maintaining cognitive reserve and risk reduction of potentially modifiable risk factors to protect against dementia, from Livingston et al. (2024).

Extant research shows promise for mindfulness addressing risk factors including depression, hypertension, smoking, alcohol consumption, social contact, physical inactivity, traumatic brain injury (TBI), and in particular, CR and sleep quality (Creswell, 2017; Livingston et al., 2024). MBIs, particularly MBCT and MBSR, can decrease depressive symptoms and risk of relapse (Ma & Teasdale, 2004; Segal et al., 2018; Strauss et al., 2014; Teasdale et al., 2000; Williams et al., 2014), with emerging evidence of benefit in older adults, though studies in older adults' depression and MBI are often small and methodologically heterogeneous (Moreno, 2019; Reangsing et al., 2021; Thomas et al., 2020; Wahbeh, 2018). MBI is linked to reduced hypertension (Conversano et al., 2019), improved blood pressure (Park & Han, 2017; Rainforth et al., 2007; Solano Lopez, 2018), and stress reduction (Baer et al., 2012; Chiesa & Serretti, 2009; Grossman et al., 2004; Khoury et al., 2015; Sharma & Rush, 2014), suggesting benefit for cardiovascular health and hypertension-related dementia risk (Conversano et al., 2021; Kulkarni et al., 1998; Liu et al., 2017). Adapted MBIs have also been effective in treating and preventing relapse of addiction-related behaviours and substance abuse (Adams et al., 2014; Black et al., 2012; Ostafin & Marlatt, 2008) by targeting cravings and their neural mechanisms in smoking and alcohol use (Bowen et al., 2021; Bowen et al., 2015; Brewer et al., 2009; Brewer et al., 2011; Froeliger et al., 2017; Garland, 2024; Westbrook et al., 2013). For low social contact, MBI may reduce loneliness (Creswell et al., 2012; Lindsay et al., 2022) and promote social engagement even when MBI is brief and individual rather than in a group (Lindsay et al., 2019). Standardised MBIs include physical activity in the form of hatha yoga, which can be adapted depending on one's physical capacity (Kabat-Zinn, 2013) – eight-week hatha yoga intervention has significantly improved executive function, attention, processing speed, and working memory in cognitively healthy older adults when compared with stretching and strengthening controls (Gothe et al., 2014; Gothe et al., 2017). Another randomized study further shows yoga improves proprioception, gait, memory, and mood-related brain function compared to a walking control (Streeter et al., 2010), and may therefore reduce risk of falling (Barrows & Fleury, 2016), the primary cause of TBI in older adults (Harvey & Close, 2012). Evidence also suggests MBIs improve symptoms and cognition after TBI (Acabchuk et al., 2021) and may increase CR, potentially mitigating cognitive decline in the context of brain injury or pathology (Malinowski & Shalamanova, 2017; Wells et al., 2019; Xiong & Doraiswamy, 2009).

**1.3.4.1. Mindfulness & Cognitive Reserve.** Neuroimaging studies support that mindfulness can induce brain plasticity (the ability to change structurally and functionally) and increase neural reserve and compensation in older adults, but these neural benefits do not always reflect behavioural or cognitive changes (Bremer et al., 2022; Yue et al., 2023). Evidence now suggests that the hippocampus retains plasticity throughout the lifespan (Gu et al., 2013; Toda & Gage, 2018), a brain structure heavily involved in memory function and observed to deteriorate structurally and functionally in AD (Mander et al., 2013). Studies have shown meditators to have superior grey matter density and increased grey matter volume in the hippocampal complex compared to non-meditators, suggesting possible protection against hippocampal atrophy (Hölzel et al., 2008; Hölzel et al., 2011; Kurth et al., 2015; Wells et al., 2019). Malinowski and Shalamanova (2017) propose that this may be because meditators have higher levels of CR. This could be due to a lifestyle difference of frequent meditation vs no meditation; consistent use of or effortful regulation of brain regions/networks (e.g., the DMN) may allow meditators to recruit these networks in later-life when age-related cognitive decline begins (Malinowski and Shalamanova, 2017). This parallels the “use it or lose it” hypothesis; that frequent intellectual/cognitive engagement buffers against age-related cognitive decline (Hultsch et al., 1999).

Another possible reason for these differences in CR between non-meditators and meditators is that mindfulness practice is associated with, and can increase, the personality trait openness to experience (Barner & Barner, 2011; Giluk, 2009; Kaviani & Hatami, 2016). Being more open to experience results in increased exposure to novel stimuli, and fluid cognitive ability (that declines with age) is based on experiencing novel stimuli from learning, reasoning, and problem-solving; dealing with the unfamiliar (Shakeel & Goghari, 2017). Processing speed, memory, executive functions, and (novel) learning ability decline with age and are considered fluid cognitive domains (Rog & Fink, 2013). Experienced meditators performing better than non-meditators in these cognitive domains (Gard, Taquet, et al., 2014) may partly reflect increased openness that promotes more frequent engagement with novel, intellectually challenging activities, positively impacting these domains (Barkan et al., 2016; McCrae & Greenberg, 2014; Tang & Braver, 2020). Engagement with novelty over the lifespan is directly associated with better cognitive function and hippocampal structure and function in late-life (Daffner et al., 2006; Valenzuela et al., 2008) and increased CR (Karsazi et al., 2021; Robertson, 2014).

Interestingly, right frontoparietal regions of the brain involved in the novelty response (Robertson, 2014) are functionally linked with the DMN (Xu et al., 2016), which as established is sensitive to the effects of ageing, and also to mindfulness practice. Furthermore, the brain's right hemisphere is critical for processing novel stimuli (Goldberg et al., 1994; McGilchrist, 2019), and neuroscientific evidence has shown mindfulness practice to have positive effects on right hemisphere brain regions (Farb et al., 2007; Taren et al., 2017; Tomasino & Fabbro, 2016) that underpin novel learning. As the evidence presented here is delineated across multiple fields of research, it is unclear whether increased mindfulness can impact CR through increased openness and exposure to novel stimuli, or whether the practice of mindfulness itself counts as novel learning and more directly impacts CR by increasing neural reserve, particularly in the DMN. This converging evidence points towards mindfulness as a factor that promotes CR, but the mechanisms of action are still largely theoretical. However, sleep quality, also implicated in DMN health and broader brain health (Cordone et al., 2019; Xie et al., 2013), is thought to be essential for building CR and thus for maintaining cognitive function (Balsamo et al., 2024). Extant research and theoretical frameworks suggest that mindfulness positively impacts sleep quality (Black et al., 2015; Shallcross et al., 2019; Zhang et al., 2015), so this is an important avenue of investigation. As early intervention is key (Livingston et al., 2024), any intervention aimed at supporting brain and cognitive health would be best implemented early, for example, in healthy older adults without cognitive impairment.

### *1.3.5 Mindfulness for Healthy Older Adults*

Findings in relation to mindfulness practice in healthy older adults are not fully clear (Fountain-Zaragoza & Prakash, 2017). Some correlational and comparison cross-sectional studies of healthy older adults have consistently demonstrated, 1) significant positive correlations between trait mindfulness and executive function (Fiocco & Mallya, 2015) and greater connectivity in the DMN of older adults with high trait mindfulness (Shaurya Prakash et al., 2013); and 2) significant differences between older cognitively unimpaired meditators and non-meditators in brain function and structure (Gard et al., 2015; Luders et al., 2016; Luders et al., 2011; Pagnoni & Cekic, 2007) and cognitive function (Prakash et al., 2012; van Leeuwen et al., 2009), in favour of meditators. Cross-sectional evidence also suggests that fluid cognitive abilities, which tend to decline with age regardless of whether neuropathology is present (Shakeel & Goghari, 2017), are preserved in experienced meditators (Gard, Taquet, et al., 2014).

Less consistent are systematic reviews investigating mindfulness and cognitive function in older adults, which have highlighted that methodological weaknesses are an issue in the field, with high risk of bias in many reviewed studies, generally small sample sizes, and varying controls (Berk et al., 2017; Fountain-Zaragoza & Prakash, 2017; Gard, Hölzel, et al., 2014; Marciniak et al., 2014). The scope of these reviews has been broad and included different study designs, older adult samples of varying cognitive ability, and had broad criteria in terms of type of mindfulness/MBI, which, while valuable for gaining a broad understanding of mindfulness in the context of cognitive ageing, do not reveal the nature of the mindfulness-cognitive function relationship with any level of exactitude, for example, in cognitively healthy older adults specifically. Overall, conclusions of these reviews indicate a promising, positive relationship between mindfulness and older adults' cognitive function, but lack certainty due to heterogeneity and pervading issues of methodological rigour. No prior reviews limited inclusion criteria to only RCTs or studies with samples of cognitively intact older adults, hence the effect of MBI on cognitive function in this population has not been ascertained. The importance of understanding types or protocols of mindfulness/MBIs and limiting inclusion criteria in systematic reviews accordingly is evidenced by Acevedo and colleagues (2016), Tang and colleagues (2015), and Marciniak and colleagues (2014). Their research demonstrated how different types of mindfulness practices can target different brain systems, cognitive domains, and risk-factors related to accelerated cognitive decline. Similarly, previous reviews have not investigated candidate mechanisms that mindfulness may work through to impact healthy older adults' cognitive function, such as sleep quality. Sleep quality is critical to healthy cognitive ageing (McCall & Watson, 2021), and is a strong candidate mechanism that mindfulness may work through to improve older adults' cognitive outcomes (Shallcross et al., 2019).

## 1.4 Sleep Quality and Cognitive Function in Ageing

Sleep is a factor that is strongly related to individuals' cognition as they enter later life (Livingston et al., 2024; McCall & Watson et al., 2021). Increased prevalence of poor sleep outcomes with ageing puts older adults at higher risk of developing cognitive impairments (McCall & Watson, 2021), and is associated with many other factors that negatively impact cognitive health, including increased hypertension (Gottlieb et al., 1999), major coronary events (Barger et al., 2017), diabetes (Yaggi et al., 2006), depression (Gagnadoux et al., 2014; Li et al., 2014), and respiratory symptoms (Gottlieb et al., 1999).

There are distinct and inter-related changes in sleep quality associated with ageing (Pace-Schott & Spencer, 2011). Demographic statistics estimate 33% of adults report sleep difficulties, a percentage which increases dramatically with age, rising to approximately 88% in adults over 65 (Ancoli-Israel & Cooke, 2005). Incidence of sleep disorders rises in late-adulthood, with research suggesting over 50% of adults older than 65 experience compromised sleep (Neikrug & Ancoli-Israel, 2010). The most prominent change in sleep quality in older adults is a reduction of total sleep time, mostly due to more awakenings occurring during the night, or wake-after-sleep-onset (WASO) (Pace-Schott & Spencer, 2011), which also decreases sleep efficiency (amount of time asleep while in bed) (Buysse et al., 2005; O'Donnell et al., 2009). In older adults, WASO is most likely to occur during the slow wave sleep (SWS) stage (Silva et al., 2010), resulting in older adults transitioning more frequently between stages of sleep, spending less time in SWS, and therefore not clearing toxic brain-metabolite accumulations as efficiently (McCall & Watson, 2021). Sleep onset latency (how fast one falls asleep after getting into bed) appears to remain stable until mid-70s, after which there is evidence of decrements in this domain (Hoch et al., 1997). Although, a more recent study found that sleep onset difficulties in healthy older adults may only have negative cognitive effects for those with low CR (Zimmerman et al., 2012).

As mentioned above, poorer sleep quality contributes to an accumulation of toxic disease-associated brain metabolites, perhaps even decades prior to appearance of cognitive symptoms and/or onset of neurodegenerative diseases (Cipriani et al., 2015). There is a bi-directional relationship between sleep disturbance and these neuropathologies developing in the DMN, which is particularly sensitive to the effects of ageing (Buckner et al., 2005; Cordone et al., 2019). There is reduced DMN function in normal age-related cognitive decline, and severe structural deterioration and loss of functional connectivity of it in pathological cognitive decline (Buckner et al., 2005; Hafkemeijer et al., 2012; Toussaint et al., 2014), which has been significantly correlated with poorer executive functioning and processing speed (Damoiseaux et al., 2008). Thus, there has been intense speculation that poor sleep quality may contribute to both normal age-related cognitive decline and the development of pathological brain changes in the DMN that increase risk of dementia, particularly AD (Scullin & Bliwise, 2015; Porter et al., 2015). Changes in sleep architecture are important to understand because these changes are found to be proportionate to brain atrophy and neuropathology accumulation in memory and executive functioning-associated brain regions (McCall & Watson, 2021).

Sleep architecture refers to the cycle of physiological sleep stages that occur during sleep as detected by polysomnography, and consists of four stages that unfold over approximately 90 minutes four to six times a night – non-rapid eye movement (nREM) sleep stages 1, 2, and 3 (SWS), and stage 4, rapid eye movement (REM) sleep (McCall & Watson, 2021). A key feature of polysomnographic measurement is measuring brain activity during sleep via electroencephalography (EEG). Frequency of oscillations in EEG signalling distinguish between sleep stages, with a progressive slowing of brain activity from theta waves in light sleep to delta waves (SWS) in the deepest stage of sleep, stage 3 (Carskadon & Rechtschaffen, 2011). The progressive slowing of frequency and increasing of amplitude of EEG readings during nREM stages of sleep is thought to reflect greater synchrony between brain regions and reduced brain activation (Pace-Schott & Spencer, 2011). REM sleep is characterised by the opposite – reduced synchrony between regions and greater brain activation, similar to that of light sleep or even consciousness (Pace-Schott & Spencer, 2011).

There are distinct age-related changes in sleep architecture (Pace-Schott & Spencer, 2011; McCall & Watson, 2021). The most consistently replicated finding of age-related sleep architecture change occurs in nREM SWS, stage 3 (Scullin & Bliwise, 2015). In young adults, SWS is more concentrated in the first ~90 minute cycle of sleep stages and decreases in subsequent cycles, while it tends to be more evenly distributed over the night in older adults, with there also typically being overall reductions of SWS (McCall &Watson, 2021). As mentioned, these alterations of SWS play a role in cognitive decline; SWS reduction in older adults is associated with decreased long term memory consolidation and retention (Westerberg et al., 2012) as well as with atrophy in brain regions/structures involved in these processes (Mander et al., 2013; Porter et al., 2015). Another feature of age-related sleep architecture change occurs in nREM stage 2, where EEG measurements tend to oscillate quickly in 0.5-2 second bursts (sleep spindles) which are also present in

SWS (McCall & Watson, 2021). Sleep spindle density, duration, and amplitude decrease drastically in older adulthood, most prominently in frontal brain regions (Ulrich, 2016). These changes are considered important in relation to cognitive decline as sleep spindles are thought to facilitate learning and memory function (Ulrich, 2016). Difficulties with sleep onset before stage 1 nREM is recognised as another factor that may signify increased risk of pathological cognitive decline in older adults (Zimmerman et al., 2012).

A growing body of literature is investigating the possibility of increased trait mindfulness and MBI addressing these sleep quality issues in adults and older adults. Cross-sectional work (Brisbon & Lachman, 2017; Howell et al., 2008), RCTs (Black et al., 2015; Gallegos et al., 2013; Gallegos et al., 2018), and theoretical frameworks (Ong et al., 2012; Shallcross et al., 2019) indicate there is potential for mindfulness to improve overall sleep quality and subdomains such as sleep onset latency, sleep efficiency, WASO, and total sleep time (Kanen et al., 2015).

### 1.5 Mindfulness and Sleep Quality

Research on mindfulness and sleep quality has garnered attention in recent years. MBIs have been used to address sleep disturbance and disorders like insomnia with success (Gong et al., 2016; Kanen  et al., 2015; Ong et al., 2014; Wang et al., 2020). In subdomains of sleep, MBI has been found to significantly improve WASO and sleep onset latency, although this particular finding was not limited to older adults (Kanen et al., 2015). RCTs have shown that MBI significantly improves sleep quality outcomes in older adults with and without insomnia (Black et al., 2015; Zhang et al., 2015). Mindfulness practice may have this positive effect on sleep due to increases in melatonin following practice (Tooley  et al., 2000), as mindfulness practice activates the pineal gland in the brain (Liou et al., 2007), a gland that contributes to the regulation of circadian rhythms and sleep-wake cycles through secretion of melatonin (Sapède & Cau, 2013). The pineal gland has only been shown to be activated in a specific type of meditation (Chinese Original Quiet Sitting) however, so it's unknown if this transfers to other forms of mindfulness practice (Liou et al., 2007). This research, although scant, is relevant as abnormal melatonin rhythms due to poor pineal gland function (caused by calcification) has been linked to neurodegeneration (Sapède & Cau, 2013).

Another link between mindfulness, sleep quality, and cognitive ageing is the function and structural integrity of the DMN. As one enters sleep and progresses through lighter nREM stages to deep nREM SWS, activity in the DMN drops correspondingly – activity is lowest during SWS (Horovitz et al., 2009). Toxic brain metabolites (e.g., AD-related pathology when highly accumulated) that damage brain integrity and disrupt function are cleared from the brain during nREM SWS (McCall & Watson, 2021; Xie et al., 2013). Mindfulness practice, or high trait mindfulness as a disposition or as a result of practice, may be able to mitigate these disruptions of sleep through improved DMN functional connectivity; a finding demonstrated in a small pilot RCT of older adults with MCI (Wells et al., 2013). The DMN has been observed to be less active in meditators when they are at rest (not at physiological rest, but cognitively, in the absence of an explicit task/overt behaviour) than non-meditators (Brewer, Worhunsky, et al., 2011). This suggests that meditators have better control over DMN-associated cognitive processes – for example, preventing mind-wandering in the absence of an explicit task, regulating distractibility (Brewer, Worhunsky, et al., 2011). Recall that poor sleep in older adults is associated with abnormal DMN activity; those with impaired sleep have difficulty regulating DMN activity (McKinnon et al., 2017). Increased DMN regulation as a result of higher trait mindfulness may explain or further contribute to understanding why MBI improves sleep onset (Kanen et al., 2015). Additionally, mindfulness practice can further help to create the conditions conducive to sleep onset – brain activity slows to levels similar to those of early-stage nREM sleep (theta waves as measured by EEG) when a deep meditative state is achieved (Aftanas & Golocheikine, 2002; Kubota et al., 2001; Tang et al., 2019).

In summary, RCTs generally report that MBIs have a beneficial impact on older adults' sleep, and neuroscientific evidence further supports this. Although few studies have explicitly investigated the relationship between mindfulness, sleep, and cognitive function in healthy older adults, current evidence provides impetus to investigate whether sleep quality mediates the relationship between mindfulness and cognitive function in older adults – particularly those without cognitive impairment, where the possibility to promote cognitive and neural reserve and reduce dementia risk is greater.

## 1.6 Rationale for the Current Research

Multiple reviews have called for further research on the nature of the mindfulness-cognitive function relationship in older adults, citing problems in extant studies such as small sample sizes (Berk et al., 2017; Farhang et al., 2019; Gard, Hölzel, et al., 2014; Marciniak et al., 2014), high risk of bias (Berk et al., 2017; Gard, Hölzel, et al., 2014; Marciniak et al., 2014) differences in meditation/mindfulness techniques (Gard, Hölzel, et al., 2014; Marciniak et al., 2014), heterogeneity of outcome measures (Farhang et al., 2019; Gard, Hölzel, et al., 2014; Marciniak et al., 2014), lack of active control groups and follow-ups (Farhang et al., 2019; Fountain-Zaragoza & Prakash, 2017; Gard, Hölzel, et al., 2014; Marciniak et al., 2014), and inconsistent modifications of MBI protocol (Gard, Hölzel, et al., 2014; Marciniak et al., 2014). Current systematic reviews and meta-analyses investigating MBI and older adults' cognitive function tend to focus on cognitively impaired older adults (Farhang et al., 2019) or combine impaired and unimpaired samples (Berk et al., 2017; Gard, Hölzel, et al., 2014; Marciniak et al., 2014). While reviews and meta-analyses with such study selection criteria can produce more powerful analyses with larger sample sizes, sample heterogeneity is introduced, which limits interpretation of results for specific populations. Study design inclusion criteria are often not limited to RCTs, meaning intervention efficacy cannot be assessed and high levels of bias may exist. Similarly, reviews and meta-analyses investigating MBI and sleep quality use broad inclusion criteria, often including interventions with differing lengths and protocols (Gong et al., 2016; Kanen et al., 2015; MacLeod et al., 2018; Samara et al., 2020), analyse wide age-range samples (Chen et al., 2020; Gong et al., 2016; Kanen et al., 2015; Y. Y. Wang et al., 2020), and either focus on insomnia (Chen et al., 2020; Gong et al., 2016; Samara et al., 2020; Y. Y. Wang et al., 2020) or pool insomnia samples with sleep disturbance, mild sleep issues, or no sleep problems (Kanen et al., 2015; MacLeod et al., 2018). There is a need for a systematic review and meta-analysis that focuses on cognitive function and sleep quality in healthy older adults without sleep disorders, and is limited to RCTs of standardised MBIs such as MBSR/MBCT.

Additionally, research is required to further examine both the impact of MBI on SCF and the relationship between SCF and trait mindfulness in older adults with SCD, preferably in RCT design. Some research has investigated mindfulness in SCD (MacAulay et al., 2022; Smart et al., 2016; Wetherell et al., 2017), but few studies have focused on SCF as an outcome, despite this measure being key in determining SCD severity. Furthermore, SCD appears to be an ideal window to address age-related reductions in sleep quality (Tsapanou et al., 2019), especially due to SCD and sleep quality associations (Exalto et al., 2022), and increased signs of AD biomarkers and pathology in SCD that may be related to poorer sleep (Yingmei et al., 2025). Even though mindfulness appears to benefit older adults' sleep quality, and sleep quality is associated with severity of SCD, no work has investigated whether sleep quality mediates the relationship between MBI and SCF. This line of research warrants further attention.

## 1.7 Thesis aims and outline

The overarching aim of this thesis is to examine whether MBI and trait mindfulness can contribute to healthy cognitive function and sleep quality in older adults without cognitive impairment. The first study (Chapter 2) will be a systematic review that synthesizes research on standardised MBIs (MBSR/MBCT) with objective cognitive function outcomes, and sleep quality as a mediator or outcome in healthy older adults. Where possible with data availability, study data will be pooled and meta-analysed. Our three objectives for Chapter 2 are to investigate 1) the effect of MBI on cognitive function; 2) the effect of MBI on sleep quality; and 3) sleep quality as a mediator of the MBI-cognitive function relationship. The second study (Chapter 3) will focus on older unimpaired adults with SCD and will consist of three secondary analyses of RCT data (SCD-Well, Medit-Ageing European Project data) (Marchant et al., 2021). Our objectives are to investigate 1) trait mindfulness' association with SCF; 2) MBI and active control's impact on SCF from baseline to post-intervention to follow-up; and 3), sleep quality as a mediator of MBI's effect on

SCF over the course of the RCT waves. Chapter 4 will comprise a General Discussion to integrate, appraise, and compare findings from each objective with extant work, suggest future research directions, acknowledge limitations, and provide synthesised interpretation and conclusion.

# Chapter 2:

# The Effect of Mindfulness-Based Intervention on Healthy Older Adults' Cognitive Function and Sleep Quality: A Systematic Review and Meta-Analysis[1]

## 2.1 Introduction

As older adults are the fastest growing demographic internationally (World Health Organization [WHO], 2020), age-related cognitive decline rates are increasing ("Alzheimer's disease facts and figures", 2021). Age-related cognitive decline is generally considered a normal, non-pathological part of the ageing process (Salthouse, 2009), albeit with great inter-individual variability (Harada et al., 2013). As discussed in detail in Ch1 (section 1.2), decline is experienced across a range of cognitive domains such as executive function, processing speed, memory, and attention (Mahendran et al., 2015). Age-related cognitive decline can therefore result in mild changes to older adults' cognitive functioning, but should be distinguished from pathological cognitive decline, which is not a normal part of ageing (Salthouse, 2012). Pathological cognitive decline goes beyond cognitive changes typically associated with normal ageing and occurs due to pathology in the brain (Schaie, 2021), such as accumulation of amyloid plaques and neurofibrillary tangles (NTs), cerebral infarcts, and Lewy bodies (Jansen et al., 2018). This type of cognitive decline results in impairment that interferes with activities of daily living, and is also associated with neurodegenerative diseases like Alzheimer's disease (AD), which is

---

[1] Published in Aging & Mental Health (shortened for publication). Citation: Colm Lannon-Boran, Caoimhe Hannigan, Joanna McHugh Power, Jonathan Lambert & Michelle Kelly (2023): The effect of mindfulness-based intervention on cognitively unimpaired older adults' cognitive function and sleep quality: a systematic review and meta-analysis, Aging & Mental Health, DOI: 10.1080/13607863.2023.2228255

the most common cause of dementia (Patterson, 2018) (see Ch1, 1.1 for account of decline trajectories).

The increase in the number of people experiencing cognitive decline and dementia presents a significant challenge, both from an economic and a broader societal perspective (Schaie, 2021). The incidence of dementia is set to triple over the next 50 years (Patterson, 2018), highlighting the pertinence of identifying effective interventions to improve cognitive functioning and/or reduce the risk of cognitive decline and dementia. As no preventative pharmacological treatments exist for dementia, there has been an increasing focus on the utility of non-pharmacological brain and cognitive-health interventions and targeting of modifiable risk-factors for cognitively healthy older adults, to reduce the risk of cognitive decline and improve cognitive function (Livingston et al., 2024). Regarding cognitively healthy older adults, it is important to determine the effects of these interventions, as this group are at an increased risk of mild cognitive impairment (MCI) and dementia due to advanced age (Mangialasche et al., 2012). One such avenue of investigation is examining the effectiveness of mindfulness-based interventions (MBI) to benefit cognitive function for cognitively healthy older adults.

## 2.2 Mindfulness, Meditation, and Mindfulness-Based Interventions

Practicing mindfulness, i.e., practicing awareness of moment-to-moment experience without judgment of the content of the experience (Kabat-Zinn, 2013), has been associated with improved psychological health and well-being (Chételat et al., 2018; Grossman et al., 2004; Hofmann et al., 2010; Khoury et al., 2015; Querstret et al., 2020). The Monitor and Acceptance Theory (MAT) is a useful framework that attempts to explain the effects of mindfulness practice/training through two basic components (Lindsay & Creswell, 2017). As discussed comprehensively in Ch1 (section 1.3.1), MAT posits that attention monitoring and acceptance are the two distinct and synergistic mechanisms underlying outcomes impacted by or related to mindfulness practice. These components are foundational parts of the two most researched and empirically validated MBIs, Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT).

MBIs teach meditation techniques and encourage participants to engage with life mindfully outside of meditation periods. In MBSR and MBCT, participants are taught and actively practice techniques such as sitting meditation, body scan, mindful movement, and hatha yoga, generally over a period of eight weeks (Goldberg et al., 2022) (see Ch1, 1.3.2 for fuller detail). As the above are empirically validated, including most/all listed elements in any MBI is important. Benefits of mindfulness practice have been suggested to extend to brain function (Davidson et al., 2003) where long-term, experienced meditators have exhibited improved cognitive and neuroimaging outcomes, and greater attentional stability for their age compared to non-meditators (Brefczynski-Lewis et al., 2007; Luders et al., 2016; Luders et al., 2009; Lutz et al., 2009). Cross-sectional and neuroimaging research examining mindfulness and cognitive function are mostly consistent with typically positive results, while RCT data is more inconsistent.

## 2.3 Mindfulness and Older Adults' Brain Health

### *2.3.1 Cross-Sectional Studies*

Cross-sectional between-participant-design and neuroimaging studies suggest that mindfulness can improve cognitive function (Prakash et al., 2012) and brain-health as measured by fMRI (Chételat et al., 2017; Luders et al., 2016). In one study, experienced Vihangam yoga meditators (*n* = 20) performed significantly better on measures of executive function, working memory, processing speed, and selective attention than inexperienced meditators (*n* = 20) matched for age (mean = 59.91), sex, and education (Prakash et al., 2012). This is supported by neuroimaging data (Chételat et al., 2017) comparing cognitively healthy experienced mindfulness practitioners (*n* = 6, mean age = 64.8) to an age-matched control group (*n* = 67, mean age = 64.8). Results showed higher grey matter volume and better metabolic ability in the experienced mindfulness group in the anterior cingulate cortex (ACC), insula, medial prefrontal cortex, higher volume in the temporo-parietal junction, and better metabolism in the posterior cingulate cortex (Chételat et al., 2017). The ACC is of particular interest here as it is thought to play a key role in selective attention (MacLeod & MacDonald, 2000), a domain observed to decline with age and that also appears to benefit from meditation (Craigmyle, 2013; West, 2004). Luders et al. (2016) took a different approach and compared the brains of long-term meditators (*n* = 50) to controls (*n* = 50) using the BrainAGE estimation framework (Franke et al., 2010), a machine-learning approach based on imaging pattern recognition. At age 50, the brains of meditators were estimated to be 7.5 years younger than those of controls according to the BrainAGE measure. These positive effects continued where meditators' brains were estimated to be an additional 1 month and 22 days younger than their chronological age for every additional year after 50. In addition to this cross-sectional evidence, intervention studies also generally report positive relationships between mindfulness and cognitive health in older adults.

### *2.3.2 Randomised-Controlled Intervention Studies*

Gothe et al. (2017) extended on the findings above (Prakash et al., 2012) with an RCT, reporting that mindfulness practice (hatha yoga) (*n* = 61) over eight weeks yielded better effects on cognitive function compared to a stretching and strengthening control (*n* = 57) in cognitively healthy older adults. Participants significantly improved on cognitive measures of executive function, working memory, and mental flexibility. This is noteworthy as hatha yoga is the type of yoga meditation taught in MBSR and MBCT. As well as this, Gothe and colleagues (2017) controlled for any potential aerobic effects by using an equally physically active control group, suggesting that mindfulness was the mechanism of change in cognitive performance. In a more recent RCT (Sevinc et al., 2021) that analysed both cognitive and neuroimaging outcomes in healthy older adults (mean age = 70.6, range = 65-80), an MBSR-based mindfulness training programme (*n* = 72) was found to be slightly more beneficial than a cognitive fitness control (*n* = 74) in improving episodic memory, executive function, and global cognition (Preclinical Alzheimer Cognitive Composite; Donohue et al., 2014), primarily in episodic memory. Note that the only reported deviation from MBSR in this study was removing the emphasis on stress reduction and instead emphasising focus and concentration, so hatha yoga remained a taught form of mindfulness practice. Improvements in the mindfulness group were uniquely associated with increased connectivity in the DMN, most notably connectivity between the right hippocampus and the right precuneus, areas that tend to deteriorate later in the lifespan and are associated with memory function (Nyberg, 2017) and novel learning (McGilchrist, 2019; Robertson, 2014). Sevinc et al. (2021) used an empirically based MBI stripped of educational and cognitive-behavioural therapy elements, thus focusing exclusively on teaching mindfulness. Although further research is required to determine optimal type of MBI, this suggests that the more ‘pure mindfulness’ interventions may be of benefit for cognitive and brain function.

The extant literature suggests that simplified interventions focusing on ‘cognitive elements’ of MBI (e.g., focused attention meditation) may be less effective than those that adhere more strictly to MBSR protocol. MBIs with significant deviations from MBSR protocol (as mentioned above) tend to show little or no significant improvements in the cognitive function of healthy older adults (e.g., Malinowski et al., 2017; Oken et al., 2017; Polsinelli et al., 2020). Deviations included using only a focused attention style mindfulness practice (mindful breath awareness) rather than incorporating multiple practices such as open awareness meditation, mindful movement, and hatha yoga (Malinowski et al., 2017; Polsinelli et al., 2020), shorter practice sessions (Malinowski et al., 2017) and less than eight weeks practice (Oken et al., 2017; Polsinelli et al., 2020). Oken et al. (2017) only used focused attention meditation and excluded hatha yoga, the importance of which has been demonstrated (Gothe et al., 2018), and practice sessions were one-on-one rather than in a group setting. In Malinowski et al.’s (2017) study, improvement in visuospatial awareness and inhibitory control were reported, but expected improvements in attention and executive function were not.

Overall, RCT studies that utilised hatha yoga meditation or included the key elements of MBSR reported improvements in executive function (Gothe et al., 2018; Sevinc et al., 2021), while other RCTs that excluded yoga meditation or other key aspects of MBSR did not report similar effects (Malinowski et al., 2017; Oken et al., 2017; Polsinelli et al., 2020). This could be attributed to the unique association yoga appears to have with increased modulation of y-aminobutyric acid (GABA) thalamic activity in the limbic system of the brain; GABA activity plays a major role in regulating stress and anxiety (Streeter et al., 2010), and stress and anxiety are associated with an increased risk of cognitive decline (Becker et al., 2018; Gulpers et al., 2016; McEwen & Sapolsky, 1995). The thalamus is also involved in attentional control (Tokoro et al., 2015), learning and episodic memory (Child & Benarroch, 2013; Torrico & Munakomi, 2025), and in regulating circadian rhythms (Steriade & Llinás, 1988; Torrico & Munakomi, 2025). There remains a lack of clarity around the impact of MBI on cognition; a number of factors may mediate or moderate this relationship including social engagement (Krueger et al., 2009; Quaglia et al., 2015), cognitive engagement (Bransby et al., 2022), increasing trait mindfulness (Kiken et al., 2015; Sevinc et al., 2021) or improving sleep quality (Wang et al., 2020; Zhang et al., 2015).

## 2.4 Sleep, Mindfulness, and the Brain

There is consensus around the importance of sleep in promoting positive cognitive outcomes (Livingston et al., 2024). Evidence suggests anomalous sleep changes occur many years before observed decline in cognitive functioning and may contribute to a greater risk of pathological cognitive decline and neurodegeneration (Cordone et al., 2019; Lim et al., 2013; Sharma et al., 2018). Andrade et al. (2018) found an association between a decrease in slow wave sleep (SWS) and increased amyloid plaque in the brains of cognitively healthy older adults – indicating that older adults, although cognitively unimpaired, may be at an increased risk of cognitive decline due to increased amyloid deposition and poorer sleep quality (for in-depth discussion see Ch1, 1.4). Branger and colleagues (2016) suggest that subjective sleep quality should be screened in cognitively healthy older adults when evaluating risk of AD, particularly in the absence of overt signs of pathological cognitive decline. Preserving sleep quality at this stage, and thus potentially preserving brain function, could be protective against future pathological cognitive decline (Lista & Hampel, 2017).

Viewed through the MAT framework, sleep quality and mindfulness could be linked by the association between sleep and sustained attention (Arnal et al., 2015; Chua et al., 2014) or prefrontal functions (Gildner et al., 2014), in that mindfulness may improve sleep, and improved sleep could contribute to the attention monitoring aspect of mindfulness outlined in MAT. From another perspective, Lau et al. (2018) cross-sectionally investigated MAT in a sleep context, and found evidence to suggest that attention monitoring and acceptance together are likely mechanisms in improving sleep quality in adults through stress reduction, but this type of mediation analysis has not been replicated in an older adult sample. In RCTs, MBI has shown potential for improving subjective sleep quality in older adults (Gallegos et al., 2016; Zhang et al., 2015) and has been more effective than a sleep hygiene intervention (Black et al., 2015). A recent meta-analysis of RCTs also found that meditation exercises improved sleep disorders in older adults (He et al., 2019). EEG research reported that brain activity regulates to levels similar to those of light sleep (slow frequency theta waves) when a deep meditative state is reached (Aftanas & Golocheikine, 2002; Kubota et al., 2001; Tang et al., 2019). This could explain the effectiveness of MBI in improving subjective sleep quality in older adults. Significant correlation between amyloid plaque levels and scores on the Pittsburgh Sleep Quality Index (PSQI) (Chen et al., 2018) suggests MBI has the potential to reduce this early marker of increased pathological cognitive decline risk by improving sleep outcomes, perhaps through regulation of brain activity, as well as by potentially maintaining functional connectivity regionally (e.g., DMN) and globally in the brain (Fam et al., 2020) (see Ch1, 1.4 for in-depth detail).

## 2.5 Existing Reviews

While prior systematic reviews have considered MBI and its impact on cognitive function in older adults in general and older cognitively impaired adults (Han, 2022; Sanchez-Lara et al., 2022), no systematic review or meta-analysis has focused on older adults without cognitive impairment, a population that could stand to gain hugely in terms of cognitive function and reduction in risk of future age-related cognitive decline. These reviews give us a broad idea of the effect of MBI on older adults in general (Sanchez-Lara et al, 2022) and on older adults with cognitive impairments and dementia (Han, 2022). Reviews have also investigated MBI and sleep quality in adults (Kim et al., 2022; Rusch et al., 2019), but these reviews were not confined to older adult populations or a specific level of cognitive ability. These reviews found MBI to have no significant effect on cognitive function in older adults in general (Sanchez-Lara et al., 2022) or in cognitively impaired older adults (Han, 2022), while recent reviews on MBI and sleep quality in adults (aged 18+) found that MBI may be effective for improving sleep (Kim et al., 2022; Rusch et al., 2019), but there was no emphasis or sub-group analysis in these reviews on sleep quality in older adults. Our review builds on the work of these earlier reviews by focusing on cognitively healthy older adults, and aiming to review studies which explored interassociations between sleep, mindfulness, and cognitive function.

### 2.6 The Current Review

To the best of our knowledge, no studies have conducted a systematic review and meta-analysis on the effect of MBIs on the cognitive function and sleep quality of cognitively healthy older adults. Therefore, this review aims to assess the effects of MBI on cognitive function and/or sleep quality in this population. Our main objectives are to systematically review extant evidence from available RCT studies investigating (i) the effect of MBI on cognitive function; (ii) the effect of MBI on sleep quality; and (iii) sleep quality as a mediator of the MBI-cognitive function relationship, in healthy older adults.

## 2.7 Methods

### Protocol and registration

The review protocol was registered on PROSPERO (https://www.crd.york.ac.uk/prospero/) with registration number CRD42021207714.

### Search Strategy

Databases searched were PubMed, Web of Science, Embase, and PsycInfo to identify RCTs or cohort studies written in English and published between 2010 and 2021. A cut-off point of 2010 was decided upon in order to ensure that included studies contain up to date literature in this rapidly developing field. Search terms included “mindfulness-based intervention” OR “MBI” OR “MBSR” OR “MBCT” OR “mindfulness” OR “mindfulness-based stress reduction” OR “mindfulness-based cognitive therapy” OR “meditation”, AND “healthy elderly” OR “elderly” OR “older adults” OR “old adults” OR “ageing” OR “cognitive ageing” OR “cognitively healthy older adults", AND/OR "sleep" OR "sleep quality". These searches were supplemented by searching reference lists of relevant review papers, Google scholar, and the author's own documents. When a satisfactorily comprehensive search had been achieved, studies were screened first by title and then by abstract. Remaining studies were screened by full-text by two independent reviewers, with any disagreements resolved through a discussion with an extended panel of advisors. See Appendix A for search strategy. Study selection is visualised in Figure 2.1 in 2.8 Results.

### Selection Criteria

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were adhered to during the selection process. Studies were included if the intervention used was MBSR, MBCT, or a MBI that used similar practices. MBIs other than MBSR/MBCT were included if they taught the same mindfulness techniques – sitting meditation, body scan, and mindful movement/hatha yoga, with a once weekly class for 8 weeks. Studies with MBIs shorter than 6 weeks were excluded due to deviating too much from MBSR protocol. The all-day mindfulness retreat in MBSR/MBCT was not a necessity for inclusion. Age criteria required a mean age of >60, with age range no lower than 55. Studies were excluded if participants had a clinical diagnosis of MCI or worse (dementia), or if the authors of a study deemed the population cognitively impaired. Studies with participants with clinical depression or anxiety, sleep disorders, or other significant medical, psychiatric, or neurological issues were also excluded (excluded studies table in Appendix B). RCT studies were considered for inclusion and must have had minimum ten participants per condition. While cohort studies were also considered for inclusion, none were identified during the search.

The primary outcome of interest was cognitive function. Sleep quality was a secondary outcome of interest. Cognitive function could be measured by global or composite measures of cognitive function, or separated into pertinent cognitive domain measures such as memory, executive function, attention, processing speed, and verbal ability. Measures of subjective cognitive decline were also considered. Sleep quality must have been measured using the PSQI.

### Data Synthesis and Analysis

Data were extracted by two independent reviewers and overseen by a mathematics support officer. Demographic information was extracted from each study, as well as any outcome data relevant to our selection criteria. Number of participants in each condition, mean change from baseline to post-test of each continuous outcome, and 95% confidence intervals were recorded. Where necessary, original authors were contacted to obtain data, and unobtainable/missing data were imputed where possible. Data were first entered into an Excel spreadsheet, and then the "meta" package in R 4.2.0 (R Core Team, 2021) was used to impute missing values and conduct the meta-analysis. Standard deviations of mean difference for pre-post intervention (first post-intervention timepoint, not a later follow-up) scores for each group were imputed from five included studies (with the exception of Moynihan et al.'s (2013) study and Smart et al.'s study (2016)) as they were required for calculating effect sizes and confidence intervals. Analyses were conducted according to guidelines in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019). A random-effects approach was used due to heterogeneity among studies in terms of sample size and control conditions. Revman 5.4 was used to create forest plots and calculate a Cohen's d effect size metric (0.2 = small effect, 0.5 = medium effect, 0.8 large effect). Heterogeneity of effect sizes was calculated using the $I^2$ statistic.

Summary characteristics of the final studies included for data extraction is shown in Appendix C. Risk of bias (Figure 2 in 2.8 Results) was assessed by two independent reviewers using the Cochrane Risk of Bias Tool as outlined in the Cochrane Handbook.

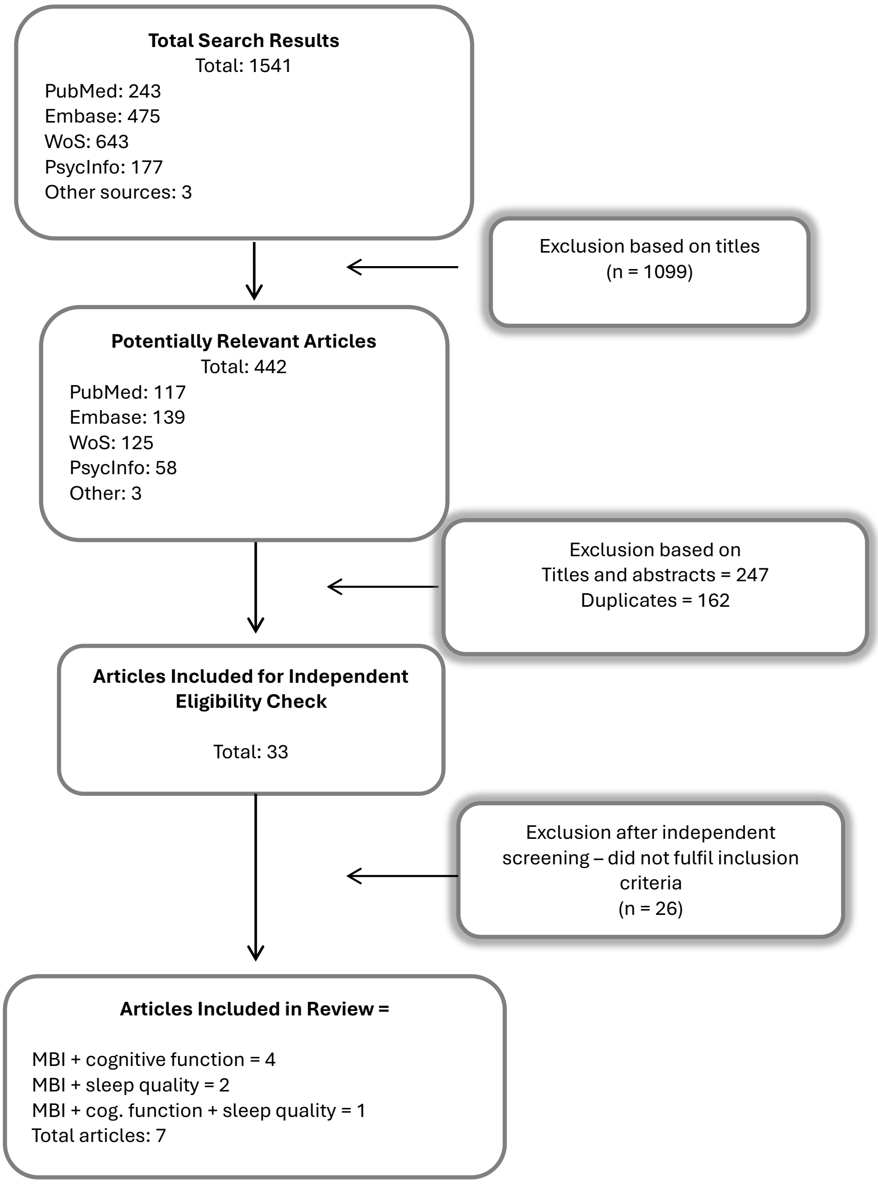
## 2.8 Results

### Study Selection

Searches of PubMed, Embase, Web of Science, and PsycInfo initially yielded 1541 results. 1099 were excluded based on title, and screening of study abstracts resulted in a further 247 being excluded. Using the duplicate removal function in Endnote, 162 duplicates were removed. Two independent reviewers screened the full texts of the remaining 33 studies, seven of which fit the inclusion criteria (see flowchart – Figure 2.1). The rationale for excluding the remaining 26 studies can be found in the table of excluded studies (Appendix B). Of the final seven included studies, four were conducted in the USA and three were conducted in Canada, and all were written and published in English.

**Figure 2.1**

*Study selection flowchart*



## Study Characteristics

The seven RCTs eligible for inclusion contained 276 participants in experimental mindfulness intervention groups, 118 waitlist controls, and 169 active controls. Samples sizes of studies varied from 36 (Smart et al., 2016) to 200 (Moynihan et al., 2013) participants. Mean age of participants in the studies was

72.04 (SD = 5.11), with no participants younger than 55. There were more female participants in total (66%) and the mean years of education was 16.5 (SD = 0.18). Participant ethnicity was not reported in all studies but samples were overwhelmingly Caucasian (91.5%) in studies where ethnicity was reported (Black et al., 2015; Bubb, 2014; Smart et al., 2016). As per the inclusion criteria outlined in the 2.7 Methods section, all included studies adhered to MBSR exactly or closely. Specifically, four studies used MBSR (Bubb, 2014; Gallegos et al., 2016; Mallya & Fiocco, 2016; Moynihan et al., 2013), one was MBSR tailored for older adults (Smart et al., 2016), another was derived from MBSR, but focused on concentration and attention rather than stress reduction (Sevinc et al., 2021), while Black and colleagues (2015) used Mindful Awareness Practices (MAPs), which contained very similar elements to MBSR.

All interventions were 8-weeks in length except for MAPs, which was 6-weeks (Black et al., 2015). Two studies investigated MBI and sleep outcomes (Black et al., 2015; Gallegos et al., 2016), four investigated MBI and cognitive function (Bubb, 2014; Mallya & Fiocco, 2016; Moynihan et al., 2013; Smart et al., 2016), and one study examined MBI and both sleep and cognitive function (Sevinc et al., 2021). One study (Gallegos et al., 2016) was an isolated secondary analysis of sleep outcomes from Moynihan and colleagues' (2013) RCT data, which had focused on executive function. Controls differed between the three studies that investigated sleep; one used a sleep hygiene education (SHE) programme (Black et al., 2015), another a cognitive fitness programme (Sevinc et al., 2021), and another a waitlist control (Gallegos et al., 2016). Controls were also diverse across the five studies that investigated cognitive function; one used a waitlist control (Moynihan et al., 2013), three used active controls (Mallya & Fiocco, 2016; Sevinc et al., 2021; Smart et al., 2016), while one had both a waitlist group and an active control group (Bubb, 2014). Active controls in the cognitive function studies included psychoeducation (Smart et al., 2016), reading and relaxation (Mallya & Fiocco, 2016), mind aerobics (Bubb, 2014), and cognitive fitness training (Sevinc et al., 2021). Study characteristics are presented in Appendix C.

## Outcome Measures

Outcome measures varied across studies. In line with prior reviews (Kelly et al., 2014a, 2014b; Martin et al., 2011) we grouped outcome measures according to cognitive domains/ability subgroups. Memory was assessed using measures of free and delayed recall. Free recall was measured using the Free and Cued Selective Reminding Test (Sevinc et al., 2021) and the California Verbal Learning Test (Mallya & Fiocco, 2016), while delayed recall was measured using the Logical Memory IIa subtest from the Wechsler Memory Scale (Sevinc et al., 2021). Executive functioning was assessed using measures of verbal fluency, attention, and processing speed. Verbal fluency was measured using the Controlled Oral Word Association Test (Mallya & Fiocco, 2016); attention was measured using the Stroop (Bubb, 2014) and Attention Network Test (Bubb, 2014); and processing speed was measured using the Digit Symbol Substitution Test (DSST) from the Wechsler Adult Intelligence Scale-Revised (Sevinc et al., 2021). Overall executive functioning was measured using the Trails Test (Bubb, 2014; Mallya & Fiocco, 2016; Moynihan et al., 2013; Sevinc et al., 2021). Global cognition was assessed using the Mini-Mental State Exam MMSE (all studies) (Folstein et al., 1975) and the ADAS-Cog (Bubb et al., 2014). Subjective cognitive function was measured using a Cognitive Complaints Index (CCI) (Smart et al., 2016). Sleep quality was measured using the PSQI (Sevinc et al., 2021; Black et al., 2015; Gallegos et al., 2016). See Appendix C for tabular format.

## Key Findings from Individual Studies

### *Sevinc et al. (2021)*

Sevinc et al. (2021) compared an 8-week MBI to a cognitive fitness training (CFT) control in a sample of healthy older adults (*N* = 146). The MBI only differed from MBSR in that it emphasised concentration and focus rather than stress reduction. They hypothesized that the MBI group's cognitive function would improve in multiple domains (episodic memory, executive function, and global cognition) compared to the control group and that improvements would be associated with improved intrinsic connectivity between the hippocampus and the posteromedial cortex (PMC) in the default mode network. This hypothesis was based on evidence that suggests mindfulness training improves, in particular, the structure and function of the hippocampus and the posterior cingulate cortex (Hölzel et al., 2011; Wells et al., 2013), regions that deteriorate with cognitive decline and are critical for healthy cognitive ageing (Dickerson & Eichenbaum, 2010; Ferreira et al., 2016; Wang et al., 2010). They also hypothesised that improvements in neuropsychological outcomes would be associated with increased intrinsic connectivity between the PMC and hippocampus, as well as an increase in grey matter volume in these regions. They took neuropsychological measures (PACC) and brain imaging measures (MRI; voxel-based morphometry to measure grey matter volume and seed-based connectivity analyses to measure functional connectivity between brain regions). Within the MBI group, there was significant small-medium improvement in cognitive function (PACC) at post-intervention compared to baseline, primarily in memory recall, while there was no significant within-group change in the cognitive fitness training (CFT) control. Between groups comparison, however, showed no statistically significant difference between MBI and CFT in cognitive function. MBI group improvement was associated with increases in intrinsic connectivity between the right hippocampus and right precuneus. This association was not found in the control group, although the between-group difference in intrinsic connectivity between the right hippocampus and right precuneus did not reach significance.

### ***Mallya & Fiocco (2016)***

Mallya and Fiocco (2016) compared an adapted MBSR programme to a reading and relaxation control (R&R) in a sample of 97 older adults. The only alterations to MBSR protocol were a shortening of daily practice to 15 minutes and removing the full day retreat from the intervention. Their hypothesis stated that MBSR would be associated with significant improvements in executive function and episodic memory. They conducted two analyses; intention to treat (ITT; intervention non-completers included in analyses) and per protocol treatment (PPT; only participants who completed the protocol treatment). They found no difference between the MBSR group and the R&R group in cognitive performance in their ITT analysis, and no significant improvement in MBSR completers (PPT) in episodic memory (free recall) compared to R&R completers ($p = 0.08$). Other outcomes in this study not relevant to this review were stress, depression, quality of life, and self-esteem. The MBSR group reported significantly better QOL in both ITT and PPT analyses, but not in any other psychosocial measures.

### ***Smart et al. (2016)***

This study’s focus was subjective cognitive function, with a sample (*N* = 36) of healthy older adults undergoing mindfulness training (MT) (*n* = 18) or a psychoeducation control (PE) (*n* = 18). The sample was also divided into those who self-reported subjective cognitive decline (SCD) (*n* = 14) and those who did not (healthy controls [HC]) (*n* = 22). Smart and colleagues hypothesised that MT would increase attentional capacity compared to PE, and expected improvements in attentional capacity to be more pronounced in the SCD subgroup. They hypothesised that participants in the MT condition would show reduced reaction times, aligning with the idea that MT would cause more stable moment-to-moment attention post-intervention. They hypothesised that MT would be associated with an increase of whole brain volume. Finally, they hypothesised that MT would be associated with positive changes on the previously described cognitive complaints index (CCI) and on self-reported mindfulness. Electroencephalography/even-related potential (EEG/ERP) was used to measure P3 amplitude, an indicator of attentional capacity. MRI was used to explore whole brain volume differences between those with SCD and HC under MT and PE conditions. They found that participants with SCD who received MT showed increased P3 amplitude post-intervention, indicating better attentional capacity compared to baseline, and equivalent to HCs’ attentional capacity post-intervention. There was no similar change in pre- and post-intervention scores of HCs’ attentional capacity. The SCD group also demonstrated a reduction in intraindividual reaction time on the Go/Nogo task, which was interpreted as an improvement in attentional stability. This improvement was observed in both SCD participants and HCs alike and was attributed to practice effects. They found a robust percentage volume brain change in the MT condition compared to PE, however, this was in a reduced sample size due to MRI data quality issues. For their final hypothesis pertaining to self-reported measures, such as the CCI, Smart and colleagues found similar improvement in psychological functioning in the SCD participants in both MT and PE conditions.

### ***Bubb (2014)***

Bubb (2014) compared an adapted MBSR condition (*n* = 32) to a waitlist control (*n* = 16) and a Mind Aerobics condition (*n* = 22) in a sample of healthy older adults (*N* = 70). They hypothesised that the adapted MBSR programme would act as a form of attention state training and that MBSR participants would show greater improvement than waitlist controls in attention and in working memory, and that there would be far transfer effects (i.e., improvements in other untrained cognitive domains). It was also hypothesised that the Mind Aerobics conditions would demonstrate training effects but wouldn't produce the same far transfer effects as MBSR. Bubb (2014) found no significant cognitive improvement in those under MBSR conditions compared to those under both waitlist and Mind Aerobics conditions. Mind Aerobics participants showed a significant improvement on visual memory, which was an expected training effect. However, there were no far transfer effects in either the MBSR or Mind Aerobics group.

### ***Moynihan et al. (2013)***

Moynihan and colleagues compared standard MBSR (*n* = 105) to a waitlist control (*n* = 103) in a sample of healthy older adults (*N* = 208). Seven participants were excluded from analyses due to missing data, though their group assignment was unspecified, resulting in a final sample size of *N* = 201. Minor modifications to MBSR were made if necessary to accommodate individualized needs – for example, hatha yoga may have been undertaken seated for certain older participants. They investigated the effect of MBSR on executive function, EEG activity, and antibody response. EEG measurement taken from the left prefrontal cortex was designed to measure emotional approach orientation. Measures of depression and perceived stress were also taken. Hypotheses stated MBSR participants would show greater improvements than waitlist controls in all measures. The MBSR group displayed significantly better executive function than waitlist control (*p* = 0.04). However, at 3 week and 21 week follow-ups, this effect was not maintained.

### ***Gallegos et al. (2016)***

Gallegos and colleagues conducted a secondary analysis of Moynihan et al.'s (2013) RCT data, examining sleep quality changes associated with MBSR compared to sleep quality changes associated with a waitlist control. Overall, they found MBSR significantly improved sleep quality compared to waitlist controls (*p* = 0.03), although the effect size was small (partial eta squared = 0.02). In their analysis, they divided the sample into subsamples based on sleep quality at baseline and found that those with worse sleep quality at baseline benefited more from MBSR. For those who scored >5 on the PSQI at baseline, MBSR had a significant (*p* = 0.02), small effect (partial eta squared = 0.05), and for those who scored >10 at baseline, MBSR had a significant (*p* = 0.04), medium effect (partial eta squared = 0.10) on sleep quality.

### ***Black et al. (2015)***

Black and colleagues' RCT was primarily concerned with sleep quality as measured by PSQI, and thus compared a standardised MBI (mindfulness awareness practices [MAPs]) (*n* = 24) to a sleep hygiene education control (SHE) (*n* = 25) in a sample of healthy older adults (*N* = 49). MAPs is similar to MBSR but differs in that overall it is shorter by 2-weeks, and daily home practice begins at 5 minutes and advances to 20 by end of intervention, while MBSR advises participants to undertake

40 minutes of practice per day from the first week. Secondary outcomes of interest were sleep-related daytime impairment outcomes and inflammatory signalling. Fatigue, depression, stress, anxiety, and insomnia symptoms were measured using linear scales and inflammatory signalling was measured via nuclear factor-kB concentration. The MAPs group's PSQI scores improved significantly compared to the SHE control ($p < 0.05$, Cohen's d = 0.89). This finding was corroborated by significant between group improvement on the Athens Insomnia Scale ($p < 0.05$, Cohen's d = 0.65). Significant improvements ($p < 0.05$) in the MAPs group compared to SHE group were also found on measures of fatigue and depression, while both groups improved on anxiety and inflammatory signalling with no significant between group differences. PSQI improvements were significantly correlated with changes in the nonreactivity sub-scale of the Five Facet Mindfulness Questionnaire ($r = -0.46$, $p = 0.04$), as were Athens Insomnia Scale scores ($r = -0.53$, $p = 0.02$). There was no such relationship found in the SHE group.

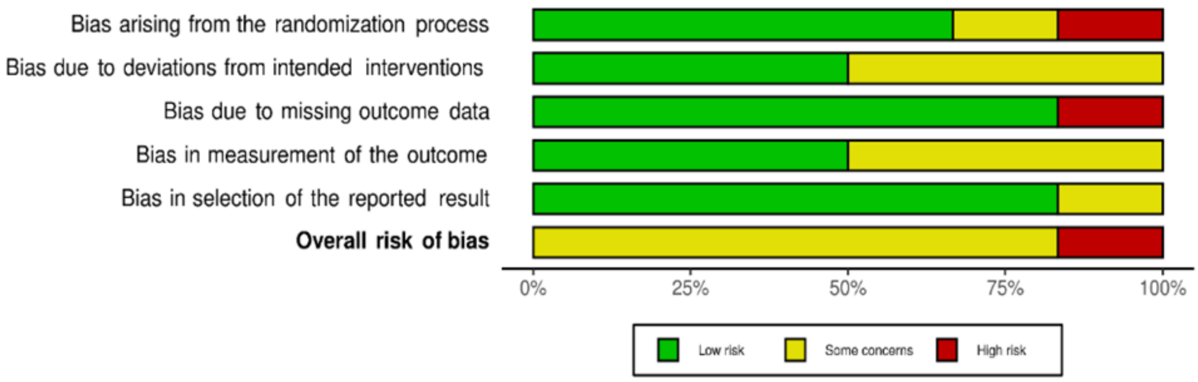
## Summary

Seven studies were selected for inclusion in the review. Five of these studies investigated MBI and cognitive function (Bubb, 2014; Moynihan et al., 2013; Mallya & Fiocco, 2016; Smart et al., 2016; Sevinc et al., 2021), while three investigated MBI and sleep quality (Black et al., 2015; Gallegos et al., 2016; Sevinc et al., 2021). One study did take measures of sleep quality and cognition in the same study and was included in sleep quality meta-analysis, but they didn't analyse the relationship between MBI, cognitive function, and sleep quality (Sevinc et al., 2021). This meant that our third objective, to explore sleep quality as a mediator of the relationship between MBI and cognitive function, could not be realised. Of the five studies investigating cognitive function, four took measures of executive function (Bubb, 2014; Moynihan et al., 2013; Mally & Fiocco, 2016; Sevinc et al., 2021), with one finding a small, significant effect of MBI on executive function (Moynihan et al., 2013). Moynihan et al.'s (2013) study could not be included in meta-analysis as standard deviation mean differences were not reported nor were they possible to impute from the reported data. Of the five studies investigating cognitive function, four investigated memory; none found a significant effect of MBI on memory (Bubb, 2014; Mally & Fiocco, 2016; Smart et al., 2016; Sevinc et al., 2021). Two out of the three studies investigating sleep quality found a significant effect of MBI on sleep quality (Black et al., 2015; Gallegos et al., 2016).

As all included studies were RCTs, overall study quality was generally high, but there were concerns in relation to outcome measurement and deviations from the intended intervention in 43% of included studies, and concerns in relation to the randomization process in one study. Risk of bias analysis showed there were some concerns with a small amount of high risk in relation to bias in the included studies (see Figure 2.2).

**Figure 2.2**

*Risk of bias*



*Note.* Cochrane Risk of Bias version 2 (RoB 2) tool showing risk level for each risk of bias domain as percentages across included studies (see 2.9.1 for further breakdown).

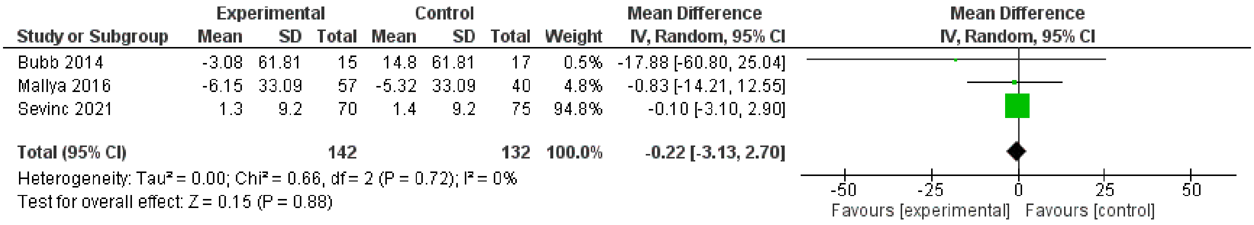
## Meta-analysis

### *Executive Function*

Data were pooled from three studies (Bubb, 2014; Mallya & Fiocco, 2016; Sevinc et al., 2021) for meta-analysis of executive function outcomes (Figure 2.3). There were 142 participants in experimental conditions and 132 in active control conditions, which consisted of Mind Aerobics, Reading & Relaxation, and cognitive fitness training. There was no significant difference between experimental and control groups (Cohen's d = 0.22, *p* = 0.88, z = 0.15, CI = -3.13, 2.70), although EF outcomes were slightly better for the MBI group compared to active controls. Heterogeneity among these studies was low ($I^2 = 0\%$). See visualised in Figure 2.3.

**Figure 2.3**

*Executive Function*



| | Experimental | | | Control | | | | Mean Difference |
|---|---|---|---|---|---|---|---|---|
| **Study or Subgroup** | **Mean** | **SD** | **Total** | **Mean** | **SD** | **Total** | **Weight** | **IV, Random, 95% CI** |
| Bubb 2014 | -3.08 | 61.81 | 15 | 14.8 | 61.81 | 17 | 0.5% | -17.88 [-60.80, 25.04] |
| Mallya 2016 | -6.15 | 33.09 | 57 | -5.32 | 33.09 | 40 | 4.8% | -0.83 [-14.21, 12.55] |
| Sevinc 2021 | 1.3 | 9.2 | 70 | 1.4 | 9.2 | 75 | 94.8% | -0.10 [-3.10, 2.90] |
| **Total (95% CI)** | | | **142** | | | **132** | **100.0%** | **-0.22 [-3.13, 2.70]** |

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.66$, df = 2 (P = 0.72); $I^2 = 0\%$

Test for overall effect: Z = 0.15 (P = 0.88)

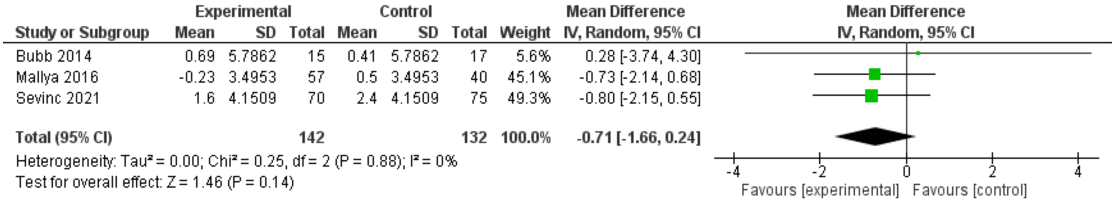
*Note.* Forest plot showing mean differences in executive function scores between experimental (MBIs) and controls for each study, with 95% confidence intervals (CI) and study weight, and pooled-random effects estimate (diamond). Negative values favour MBI and positive values favour controls.

### *Memory*

There were three studies with sufficiently reported data on memory outcomes that could be pooled for meta-analysis (Bubb, 2014; Mallya & Fiocco, 2016, & Sevinc et al., 2021). Heterogeneity was low enough for meta-analysis to be conducted ($I^2 = 0\%$). All three of these studies included measures of delayed recall, and two of them had similar measures of free recall (Mallya & Fiocco, 2016; Sevinc et al., 2021). In experimental (MBI) conditions there were 142 participants and in the active control conditions there were 132. For delayed recall, the experimental condition was favoured but the difference in effect was not statistically significant (Cohen's d = 0.7, $p = 0.14$, z = 1.46, CI = -1.66, 1.24). See Figure 2.4. For free recall, heterogeneity within Mallya & Fiocco and Sevinc and colleagues' studies was also low enough to conduct meta-analysis ($I^2 = 45\%$). In Sevinc et al.'s study the cognitive fitness training control improved more in free recall than the MBI group, and in Mallya & Fiocco's study (weighted 55.6%) the MBI group improved more. Overall, the experimental condition was very slightly favoured (Cohen's d = 0.05, $p = 0.95$, z = 0.07, CI = -1.54, 1.44). See visualised in Figure 2.5.

**Figure 2.4**

*Delayed Recall*



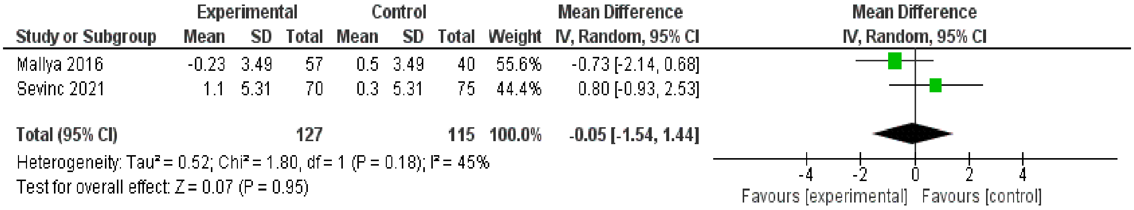
| | Experimental | | | Control | | | | Mean Difference |
|---|---|---|---|---|---|---|---|---|
| **Study or Subgroup** | **Mean** | **SD** | **Total** | **Mean** | **SD** | **Total** | **Weight** | **IV, Random, 95% CI** |
| Bubb 2014 | 0.69 | 5.7862 | 15 | 0.41 | 5.7862 | 17 | 5.6% | 0.28 [-3.74, 4.30] |
| Mallya 2016 | -0.23 | 3.4953 | 57 | 0.5 | 3.4953 | 40 | 45.1% | -0.73 [-2.14, 0.68] |
| Sevinc 2021 | 1.6 | 4.1509 | 70 | 2.4 | 4.1509 | 75 | 49.3% | -0.80 [-2.15, 0.55] |
| **Total (95% CI)** | | | **142** | | | **132** | **100.0%** | **-0.71 [-1.66, 0.24]** |

Heterogeneity: Tau² = 0.00; Chi² = 0.25, df = 2 (P = 0.88); I² = 0%

Test for overall effect: Z = 1.46 (P = 0.14)

**Figure 2.5**

*Free Recall*



| | Experimental | | | Control | | | | Mean Difference |
|---|---|---|---|---|---|---|---|---|
| Study or Subgroup | Mean | SD | Total | Mean | SD | Total | Weight | IV, Random, 95% CI |
| Mallya 2016 | -0.23 | 3.49 | 57 | 0.5 | 3.49 | 40 | 55.6% | -0.73 [-2.14, 0.68] |
| Sevinc 2021 | 1.1 | 5.31 | 70 | 0.3 | 5.31 | 75 | 44.4% | 0.80 [-0.93, 2.53] |
| **Total (95% CI)** | | | **127** | | | **115** | **100.0%** | **-0.05 [-1.54, 1.44]** |

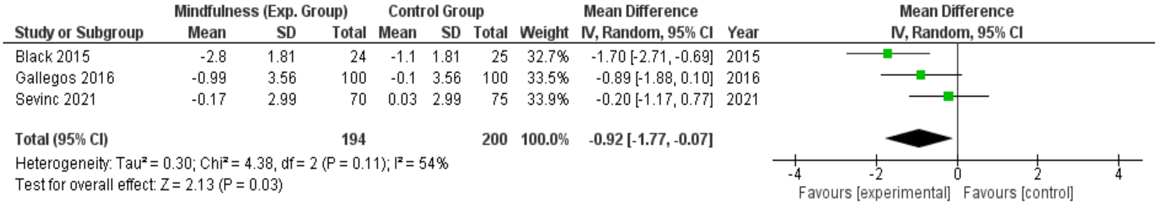
Heterogeneity: Tau² = 0.52; Chi² = 1.80, df = 1 (P = 0.18); I² = 45%
Test for overall effect: Z = 0.07 (P = 0.95)

### *Sleep Quality*

Three studies were pooled for meta-analysis of sleep quality outcomes (Black et al., 2015; Gallegos et al., 2016; Sevinc et al., 2021). Heterogeneity was moderate between the three studies ($I^2 = 54\%$). Two of these studies used active controls, sleep hygiene education (Black et al., 2015) and cognitive fitness training (Sevinc et al., 2021), and the other used a waitlist control (Gallegos et al., 2016). In experimental conditions there were 194 participants and in control conditions there were 200 participants. MBI had a significant overall effect on sleep quality (Cohen's d = 0.9, *p* = 0.03, z = 2.13, CI = -1.77, -0.77). The MBI condition was favoured over controls to a significant level with a large effect size. See visualised in Figure 2.6.

**Figure 2.6**

*Sleep Quality*



| | Mindfulness (Exp. Group) | | | Control Group | | | | Mean Difference | |
|---|---|---|---|---|---|---|---|---|---|
| Study or Subgroup | Mean | SD | Total | Mean | SD | Total | Weight | IV, Random, 95% CI | Year |
| Black 2015 | -2.8 | 1.81 | 24 | -1.1 | 1.81 | 25 | 32.7% | -1.70 [-2.71, -0.69] | 2015 |
| Gallegos 2016 | -0.99 | 3.56 | 100 | -0.1 | 3.56 | 100 | 33.5% | -0.89 [-1.88, 0.10] | 2016 |
| Sevinc 2021 | -0.17 | 2.99 | 70 | 0.03 | 2.99 | 75 | 33.9% | -0.20 [-1.17, 0.77] | 2021 |
| **Total (95% CI)** | | | **194** | | | **200** | **100.0%** | **-0.92 [-1.77, -0.07]** | |

Heterogeneity: Tau² = 0.30; Chi² = 4.38, df = 2 (P = 0.11); I² = 54%
Test for overall effect: Z = 2.13 (P = 0.03)

## 2.9 Discussion

This systematic review and meta-analysis aimed to assess the effects of MBI on cognitive function and sleep quality in healthy older adults. The first objective was to systematically review extant evidence from available RCTs investigating the effect of MBI on cognitive function in our population of interest. In relation to this objective, we were able to conduct meta-analysis on two distinct types of memory (free recall and delayed recall) and on executive function. Three studies' data were pooled for analysis on executive function and delayed recall (Bubb, 2014; Mallya & Fiocco, 2016; Sevinc et al., 2021) and two were pooled for analysis on free recall (Mallya & Fiocco, 2016; Sevinc et al., 2021). Compared to controls, MBI had a non-significant effect on all of these cognitive domains. The second objective was to systematically review extant evidence from available RCTs investigating the effect of MBI on sleep quality in our population of interest. Three studies' data were pooled for analysis on sleep quality (Black et al., 2015; Gallegos et al., 2016; Sevinc et al., 2021). Compared to controls, MBI had a significant effect on sleep quality with a large effect size. Our third objective pertained to reviewing studies that investigated sleep quality as a mediator of the MBI-cognitive function relationship. To the best of our knowledge, no RCTs exist that examine this relationship in healthy older adults and therefore this objective could not be addressed.

Outside of meta-analysis, and also in relation to the first objective, Moynihan et al. (2013) reported a small but significant effect of MBI on executive function, but this was compared to a waitlist control, making a significant finding more likely. Smart et al.'s (2016) study found that MBI produced increased attentional capacity in those with SCD, attentional capacity that was equivalent to non-SCD controls' (nSCD) capacity at baseline. The attentional capacity of nSCDs did not change in this study, while the SCD participants did. Despite this finding coming from a small sample size, this is perhaps an indication that those without SCD will not benefit, or will not show any detectable cognitive benefit, from engaging in MBI, whereas cognitively healthy individuals who self-report memory/cognitive issues (SCD), but do not reach objective thresholds for cognitive impairment, may benefit. It is possible that some cognitive measures are not sensitive enough to detect changes in cognitive function in cognitively healthy older adults, but when combined with different measurement techniques (EEG, brain scans), as in Smart et al.'s (2016) study, unique differences between groups practicing mindfulness and controls are found. As another example of this, Sevinc et al. (2021) reported no significant difference between MBI and CFT conditions in improving cognitive outcomes (both conditions improved cognitive function), but they did find that memory improvement in the MBI group was uniquely and significantly associated with increases in intrinsic connectivity between the right hippocampus and right precuneus. Previous cross-sectional work on older experienced meditators and MBI trial research also found these areas of the brain, which are involved in executive function and memory, to have better function than in non-meditators and controls (Chételat et al., 2017; Shaurya Prakash et al., 2013; Wells et al., 2013). Another option in relation to measurement sensitivity is to make greater use of cognitive tests that are associated with temporally mediated domains, such as verbal fluency (Pihlajamäki et al., 2000), which tend to be more sensitive to cognitive and neural change in unimpaired older adults (Brickman et al., 2005).

It is unclear whether MBI has an effect on cognitive function in healthy older adults. It is possible that 8-weeks of mindfulness practice, as is practiced in most standardised MBIs, is not a long enough time for improvement in awareness/attention monitoring that MAT (Lindsay & Creswell, 2017) posits cognitive effects to be detectable by neuropsychological measures in those who are cognitively healthy (Kurth et al., 2017). This could be why cross-sectional research shows a much clearer disparity between cognitive function in meditators and non-meditators – generally, experienced meditators in these studies have practiced mindfulness for many years, rather than 8 weeks (e.g., Luders et al., 2016). Through the lens of MAT, it is possible that longer than 8-weeks of practice is necessary for attention monitoring/awareness improvements, while less time is needed for improvements in acceptance. Equally, however, these differences could be due to other extraneous and unique characteristics that meditators tend to share, that non-meditators do not possess. Recall, though, that in both Smart et al.'s (2016) and Sevinc et al.'s (2021) studies, imaging and brain activity measures did produce significant findings from 8-week MBI in older adults without cognitive impairment. Ideally, RCTs of MBIs longer than 8-weeks with multiple follow-ups would help determine if these brain changes lead to cognitive improvement in longer term practice (Kurth et al., 2017; Tang et al., 2016). These views are shared by Luders et al. (2014), who, in their review, recommended that future neuroimaging research on mindfulness and brain ageing would "have to include neurocognitive measures to address if the preservation of brain tissue is related to the preservation of mental capacities, and which cognitive domains are particularly affected… longitudinal studies – preferably using random assignments to mindfulness interventions and an active control condition – will help to discriminate between cause and effect" (p. 86). They also stated more research on normative (cognitively unimpaired) samples was required – Smart et al. (2016) and Sevinc et al. (2021) have since conducted such research but further randomised longitudinal design studies are still needed to address the cognitive and brain-preserving potential of mindfulness practice. Gard, Hölzel, et al. (2014), too, emphasised the importance of establishing in the future "what neural changes underlie the effects of meditation on cognitive function" (p.

101) (i.e., brain imaging measurement and neuropsychological measurement), as well as the importance of implementing long-term follow-ups in an RCT setting.

Findings in relation to our second objective on sleep quality are clearer. Previous reviews have had similar findings on the effects of MBI on sleep in a broader age category not limited to older adults (Gong et al., 2016; Y. Y. Wang et al., 2020), while an RCT on older adults (that included cognitively impaired older adults) also found MBI to have a positive and significant effect on sleep (Zhang et al., 2015). Although these studies (Gong et al., 2016; Y.Y Wang et al., 2020; Zhang et al., 2015) focused on a sleep disorder – insomnia – the PSQI was the scale used to measure severity of insomnia symptoms. Our results provide further evidence that MBI is effective for improving subjective sleep quality as measured by PSQI in older, cognitively healthy adults without sleep disorder. Contrastingly, prior research on MBI and objective sleep measures like actigraphy have found no effect of MBI on objective sleep quality (Kanen et al., 2015). This is perhaps an indication that MBI improves specific aspects of sleep quality, like sleep latency, which may not necessarily improve overall objective sleep quality, but would aid the individual in falling asleep efficiently. There is evidence of a significant association between subjective sleep latency and objective (polysomnographic) sleep latency in cognitively healthy older adults (O'Donnell et al., 2009). However, other work has indicated that subjective sleep measures should not be used as a substitute for objective measures of sleep quality in older adults, although this is specifically in relation to actigraphy (Landry et al., 2015). MBI’s relationship with sub-scales on the PSQI (such as sleep latency) warrants closer scrutiny, especially given that previous findings show the PSQI sub-domain of sleep latency is significantly correlated with objective polysomnographic measures of sleep latency (O’Donnell et al., 2009).

MAT posits that both awareness/attention monitoring and acceptance are the essential mechanisms of mindfulness practice having a beneficial effect on health outcomes (Lindsay & Creswell, 2017). By modifying how one reacts to experience (acceptance of what is being monitored in the present), stress and emotional reactivity can be reduced. A reduction in stress and emotional reactivity before attempting to initiate sleep could improve sleep latency, and partially explain the significant effect of MBI on sleep quality. Lau and colleagues’ (2018) findings support the notion that improvements in both mechanistic elements of MAT are necessary for improved sleep, suggesting they may facilitate disengagement from maladaptive thinking and reduce stress and arousal. Our findings support this interpretation in cognitively healthy older adults. By implementing MBIs that teach attention monitoring and acceptance, sleep quality may be improved through a reduction in stress and emotional reactivity, which is conducive to sleep initiation and maintenance.

### 2.9.1 Limitations

A number of limiting issues were encountered during the undertaking of this systematic review. Cognitive domain definitions differed across the included studies. While many were similar and in agreement over what certain neuropsychological tests measured, some definitions varied, for example, Bubb (2014) defined the Trail-Making test as a measure of attention, while Mallya and Fiocco (2016) and Moynihan et al. (2013) stated attention was but one domain being measured within the test, and that the Trail-Making test was measuring executive function. If there was broader agreement on domains and their measurement tools, more meaningful meta-analyses could be conducted in future. In the current review, imputing standardised scores for the purpose of pooled meta-analyses should have mitigated this limitation to an extent. However, having less imputations to do with more congruent data would result in less risk of error occurring, and lead to more streamlined pooled analysis.

It proved difficult to obtain access to full datasets for the final studies included in the review, which limited the power of the meta-analyses that could be conducted. Even access to certain elements of study datasets, like standard deviation mean difference scores, would have greatly benefitted this review and meta-analysis, but most authors could not be contacted. This problem seems a reoccurring one in scientific research in general, as outlined in research conducted by Wilkinson et al. (2016) and more recently by Gabelica et al. (2022). Gabelica and colleagues (2022) requested access to data from 1792 studies; 93% of contacted authors did not respond or declined to share their data, showing the pervasiveness of this problem.

Risk of bias was a limitation of this review, and a concern that should be addressed in future trials in this field of study. One study's risk of bias assessment produced a "high concern" of bias rating (Bubb, 2014), while all other included studies were classified as having "some concerns". The majority of concerns that drove these results fell under "bias in measurement of the outcome" and "bias due to deviations from the intended intervention". No study scored "low risk" in every domain of risk of bias assessment, although Black et al.'s (2015) study and Moynihan et al.'s (2013) only scored "some concerns" in one domain and low on everything else, which the RoB 2 tool still interpreted as "some concerns". The overall risk of bias assessment indicated there were "some concerns" with a small amount of “high risk”, which is visualised in the Risk of Bias table (Figure 2.2). Future RCTs could also benefit from addressing the somewhat concerning risk of bias present in the studies included in this review by using more rigorous randomization protocols and reporting all outcome data, or making all data accessible through an open-data repository. Such access is imperative for future reviews and meta-analyses.

Finally, no two studies in the review used the same type of control condition. A strength would be that the majority of controls were active controls, while one was waitlist. Active controls still varied though, including cognitive fitness training, reading and relaxation, psychoeducation, Mind Aerobics, and for sleep outcomes, Sleep Hygiene Education, waitlist, and cognitive fitness training. Ideally, control groups would be very similar or the same, and in the context of mindfulness research, would focus on improving cognition/sleep with no element of mindfulness in the condition.

### 2.9.2 Conclusions & Future Directions

The current study found no significant effect of MBI on healthy older adults’ cognitive function, but did find evidence of MBI having a significant, large effect on sleep quality in this population. Analysis of three pooled studies, however, is insufficient to ascertain certainty in terms of MBI effect on cognitive function or sleep quality. Future studies should strive to achieve rigorous design with multiple follow-ups, have large samples, and use a standardised MBI, which would allow for future systematic reviews and meta-analyses to conduct more powerful and meaningful analysis. This is in agreement with other recent reviews in the area that concluded the methodological quality of future studies needs to improve (Han, 2022;

Sanchez-Lara et al., 2022). Preferably, future studies would also integrate both imaging and neuropsychological measures, especially in cognitively healthy older adult samples where cognitive change might be more difficult to detect.

To the best of our knowledge, there is a major dearth of research investigating mindfulness, cognitive function, and sleep quality in samples of older adults without cognitive impairment. Extant systematic reviews have not attempted to review or meta-analyse data from studies that investigated the relationships between mindfulness, sleep, and cognitive function in older adults. Although we could not address this objective of ours, as no such studies were found in our comprehensive search, having it as an objective still highlighted this gap in the literature, something which past reviews failed to do. As sleep quality deteriorates with age and is important for brain health and cognitive function in ageing (Scullin & Bliwise, 2015), and our results suggest MBI is effective for improving sleep quality, it is suggested that future research on healthy older adults utilise sleep quality measures when investigating the relationship between MBI and cognitive function in ageing. Sleep disturbances, including problems initiating sleep (sleep latency), are some of the earliest preclinical symptoms of dementia and may begin decades before there is noticeable cognitive decline (Cipriani et al., 2015 in Schaie, 2021, p. 107). In relation to this, and as suggested by Branger et al. (2016), sleep quality measures could be useful for screening older adults who may be at higher risk of future cognitive decline despite presenting as cognitively healthy. Low scores on the PSQI can be indicative of future cognitive decline risk (Potvin et al., 2012) and could therefore potentially detect risk that would not be detectable on cognitive screening tests carried out with cognitively unimpaired individuals. Likewise, scoring poorly on a subjective cognition measure might be an option for screening healthy older adults for higher risk of cognitive impairment (van Harten et al., 2018). Those who have poor sleep quality as well as SCD, even if objectively cognitively healthy, are at higher risk of developing pathological cognitive decline (Tsapanou et al., 2019; Xu et al., 2020), and therefore could potentially benefit greatly from intervention. In the context of profiles that could benefit most from intervention, future work should also consider factors specific to women such as menopause and vasomotor symptoms, given their associations with changes in cognitive function and sleep (Gava et al., 2019), as well as evidence that MBI may improve vasomotor symptoms (Chen et al., 2021) and sleep (Darehzereshki et al., 2022) in menopause. Studies conducted over a longer time period investigating the relationships between mindfulness, sleep, and cognitive function, preferably including menopause-related factors, are desirable and necessary to ascertain if MBI could influence cognitive trajectory by improving sleep outcomes.

A final point of discussion to be made with regard to the age-related increase of cognitive decline risk is that learning or practicing mindfulness through meditation may actually become more difficult the older one gets; many aspects of attentional ability deteriorate with age (Glisky, 2007; Reuter et al., 2019; Vallesi et al., 2021), and a large part of mindfulness practice involves exercising the ability to attend to a chosen stimulus in the present moment. Although not discounting the potential of MBI in cognitively impaired older adults (see Quintana-Hernandez et al. (2016) as an example) the current evidence points towards investigating a model where increasing mindfulness before stages of cognitive impairment could positively influence cognition and cognitive decline risk through changing sleep quality outcomes. Thus, it is recommended that future research strive to understand the relationship between mindfulness, sleep quality, and cognitive function in cognitively healthy older adults with subjective cognitive issues. It is recommended that analysis techniques such as structural equation modelling (SEM) or PROCESS mediation (Hayes & Little, 2022) be implemented to ascertain the mediating role of sleep quality in this context. These types of analysis are powerful tools for understanding effects of mediating and latent variables and have the ability to handle missing data and account for bias (SEM). Other work has called for future research to strive to understand the mechanisms underlying the effect of mindfulness on cognitive function (Reynolds et al., 2021; Whitfield, Barnhofer, Acabchuk, et al., 2022), and SEM or mediation are ideal analysis methods to achieve this goal.

# Chapter 3:

## Trait Mindfulness, Mindfulness-Based Intervention, and Subjective Cognitive Function and Sleep Quality in Older Adults with Subjective Cognitive Decline

### 3.1 Introduction

Up to 45% of dementia risk is attributable to modifiable lifestyle factors, underscoring the importance of early identification of at-risk individuals so that appropriate interventions can be implemented (Livingston et al., 2024). Recall that subjective cognitive decline (SCD) has arisen as a potential early indicator of dementia risk (see Ch1, 1.1), with SCD more likely to be impacted by lifestyle modifications or intervention than later stages of cognitive decline (Espinoza Jeraldo et al., 2024; Munro et al., 2023). SCD is broadly defined as self-reported persistent worsening of subjective cognitive function (SCF) despite normative scores on objective cognitive tests (Jessen et al., 2020). Ambiguities in its conceptualisation arise mainly from heterogenous SCF measures (Munro et al., 2023; Rabin et al., 2015), as well as from what is considered “normal” objective cognitive function, as those with SCD often show subtle objective cognitive decrements (within normal ranges) compared to controls (Li et al., 2023; López-Higes et al., 2024; Pavel et al., 2022). So, objective measures may be useful in identifying this cognitively healthy – yet at-risk – group (Pavel et al., 2022). Yet, neuroimaging evidence indicates that SCF measures may be more sensitive to underlying cognitive change than objective measures – there are significant correlations between subjective cognitive outcomes and incipient neuropathological decline, not found with objective cognitive outcomes (Sharma et al., 2021; Stewart, 2012). These challenges in defining and measuring SCD are responded to differently across studies, which is likely to produce heterogeneous SCD groups across studies, in turn complicating estimates of SCD prevalence and the subsequent risk of progression to MCI or dementia (Si et al., 2020).

Based on the current (likely problematic) findings, SCD prevalence increases with age and is associated with progression to MCI and later dementia (Slot et al., 2019). SCD is prevalent in approximately 25% of older adults (> 60 years) (Röhr et al., 2020), with rates rising to 25–50% in those over 65 and up to 88% in those over 85 years (Reisberg et al., 2008; Reisberg et al., 2010; Si et al., 2020). Across four longitudinal studies and reviews, about 10-25% of individuals with SCD progressed to MCI and 10% progressed to dementia (mainly AD) over 2-5 years, with SCD conferring just over double the risk of dementia progression compared to those without SCD, indicating that SCD marks a meaningful elevation in risk (Mitchell et al., 2014; Slot et al., 2019; Wallin et al., 2016; Wolfsgruber et al., 2017). Variation in reported risk of progression from SCD to dementia across studies is apparent here, which may be due to the aforementioned methodological and conceptual heterogeneity in SCD literature (Jessen et al., 2020; Luck et al., 2015; Roehr et al., 2016; Waldorff et al., 2012), as well as overlapping influences of psychological wellbeing and personality traits in SCD (Pavel et al., 2022; Aschwanden et al., 2022). Trait mindfulness is a factor that may also have direct and indirect influences on SCD severity and its observed comorbidities (MacAulay et al., 2022).

### 3.2 Mindfulness and Subjective Cognitive Decline

Mindfulness has emerged as a promising protective factor against age-related cognitive decline, including SCD (Chételat et al., 2017; Gard, Hölzel, et al., 2014; Lutz et al., 2021). Cross-sectional evidence highlights a possible bidirectional relationship, where SCF improvements reinforce aspects of trait mindfulness and vice versa (MacAulay et al., 2022). Evidence from MBI trials further supports the idea that practicing mindfulness may be beneficial for SCF. A recent meta-analysis of 111 randomized-controlled trials (RCTs) showed that MBI had a significant small to moderate effect on SCF outcomes (*N* = 4,278) in children, adolescents, and middle-aged adults; although no meta-analysed studies included SCF outcomes in older adults with SCD (Zainal & Newman, 2024). Smart and colleagues (2016), in a small pilot RCT (*n* = 38), found significant improvements in SCF at post-intervention in all participants with SCD (see Ch2, 2.8 and 2.9 for detailed results and study evaluation). The measure used for SCF was also an amalgamation of items selected from three measures, limiting inferences that can be made to more standardised measures of SCF, a pervasive issue in SCD literature highlighted by Jessen et al. (2020). One mixed-methods study focused on subjective memory function – another example of measurement heterogeneity – and showed feasibility and acceptability of standardised 8-week MBI (MBSR) for SCD. It further showed qualitative benefits (e.g., increased acceptance of cognitive concerns) and modest psychological improvements (depression, anxiety, quality of life) post-MBI, but uncontrolled design, lack of control group, and small sample are notable limitations. There were no quantitative post-intervention changes in their subjective cognitive measure, contrary to Smart and colleagues’ (2016) more rigorous findings.

Trait mindfulness and MBI (see Ch1, 1.3.1 and 1.3.2 for distinction), may improve aforementioned outcomes in individuals with SCD through interconnected neurobiological and psychological pathways (Lutz et al., 2021; Smart et al., 2016; Strikwerda-Brown et al., 2021). Findings from various neuroimaging studies support the idea that mindfulness may preserve brain function, and thus cognitive function, for those with SCD. Trait mindfulness and MBI are associated with preserved grey matter density in attention-related brain regions and enhanced connectivity of the default mode network (DMN) (Bremer et al., 2022; Hasenkamp & Barsalou, 2012). DMN brain regions are vulnerable to AD-related pathology in SCD (Amariglio et al., 2018; Wang et al., 2013), especially among participants with SCD and elevated worry (Verfaillie et al., 2019), which MBI may target specifically (Franco et al., 2017; Lenze et al., 2014). The potential neuroprotective effects of trait mindfulness and MBI may counteract structural and functional declines driven by increased amyloid deposition and cortical thinning, which are hallmark characteristics of AD pathology (Buckner et al., 2005; Ossenkoppele et al., 2015), and are more pronounced in SCD vs non-SCD individuals (Lim et al., 2019). Furthermore, MBI may be beneficial for persons with SCD through reducing cognitive decline accelerated by stress, i.e., the stress-buffering model (MacAulay et al., 2023; Yegorov et al., 2020), by improving emotional regulation (Kabat-Zinn, 2013; Prakash et al., 2015; Sharma & Rush, 2014), by reducing inflammatory markers associated with faster cognitive ageing (Cahn et al., 2017; Creswell et al., 2012), by regulating cortisol responses, and by reducing worry, anxiety, and depression (Wetherell et al., 2017). In addition, promoting non-judgmental awareness (a facet of trait mindfulness) through MBI improves cognitive reappraisal (i.e., mindfulness-to-meaning theory), mitigating negative interpretations of age-related cognitive changes that often exacerbate SCD (Cappa et al., 2024; Garland et al., 2015; Garland et al., 2017).

Overall, investigations into trait mindfulness and SCF in healthy older adults at-risk of dementia suggest there is a link, and MBI has been found feasible and particularly suitable for older adults with SCD in limited research. Examining mechanisms through which mindfulness may affect SCF is also important – one potential mechanism lacking investigation in the context of mindfulness and subjective cognitive outcomes is sleep quality. In our systematic review and meta-analysis in Ch2, we found that MBI positively impacted sleep quality in healthy older adults (Lannon-Boran et al., 2023), while extant evidence also suggests a relationship between sleep quality and SCF in healthy older adults with SCD (Siddarth et al., 2021; Sun et al., 2024).

## 3.3 Mindfulness, Sleep Quality, & Subjective Cognitive Function

Mindfulness can improve sleep quality in older adults without cognitive impairment (Lannon-Boran et al., 2023; Morone et al., 2008; Weber et al., 2020). In RCTs (demonstrated in Ch2 meta-analysis) MBI appears effective for improving subjective sleep quality in older cognitively unimpaired adults without sleep disorders (Gallegos et al., 2018), even compared to a sleep hygiene intervention (Black et al., 2015). In other meta-analysis which included non-standardised MBIs, pooled RCTs show that mindfulness exercises improve sleep disorders in older adults (He et al., 2019), and mind-body interventions (including MBI) improve sleep in older adults with poor baseline sleep quality (Li et al., 2025). Research on the impact of mindfulness on sleep quality in older adults has overwhelmingly focused on those with poor sleep quality, sleep disturbance, or insomnia (Garland et al., 2016; Gong et al., 2016; Kanen et al., 2015; Li et al., 2025), as evidenced further by the limited amount of RCTs fitting Ch2's inclusion criteria for systematic review. This may be because older adults are more susceptible to sleep disruption (Buysse et al., 2005; Kim & Duffy, 2018). Notably, this susceptibility to declining sleep quality appears to be stronger in older adults with SCD (Exalto et al., 2022; Kim et al., 2021), with sleep quality implicated as a possible risk factor for progression to cognitive impairment in those with SCD (Spira et al., 2014; Sun et al., 2024). Consequently, it is important to consider if mindfulness effects sleep quality in those with SCD.

Increased trait mindfulness might contribute to improved sleep in SCD through targeting a combination of cognitive and behavioural processes that tend to occur sequentially and exacerbate sleep issues (Shallcross et al., 2019), as discussed in Ch1 (section 1.5). Furthermore, the physiological effects of mindfulness on body relaxation and cortisol regulation (Wetherell et al., 2017) are important in the context of improving sleep (Pulopulos et al., 2020). Neurophysiologically, electroencephalography (EEG) studies show that global brain activity regulates to levels similar to those of light sleep (slow frequency theta waves) when a mindfulness state is reached (Aftanas & Golocheikine, 2002; Kubota et al., 2001; Tang et al., 2019), which could explain why mindfulness appears to improve sleep quality in older adults.

As sleep quality is related to key brain health markers (Branger et al., 2016), the positive relationship between mindfulness and sleep in older adults may also have broader neurological implications. Neuroimaging evidence shows that poor regulatory ability of DMN activity (i.e., regulating activity in this network between high and low activity) is associated with rumination, anxiety, and sleep disturbances (Marques et al., 2018; Regen et al., 2016). DMN regulation may be improved by mindfulness (Rahrig et al., 2022) and promote better sleep – for example, Killgore and colleagues (2023) suggest that suppressing DMN activity prior to sleep may improve sleep quality. Improved sleep from better DMN function may reduce accumulation of AD-related brain pathology (McCall & Watson, 2021), as discussed in detail in Ch1 (section 1.5). Given that SCD prevalence and symptom severity (as measured by SCF) is associated with sleep quality (Exalto et al., 2022; Lee et al., 2020; Leng et al., 2020), as well as with increased burden of AD-related brain pathology and DMN atrophy (Amariglio et al., 2018; Amariglio et al., 2015; Wang et al., 2013), investigating mindfulness as a method of improving sleep and subsequent SCF severity is warranted.

Sleep quality and SCF are associated (Exalto et al., 2022; Tsapanou et al., 2019; Jessen et al., 2020; Siddarth et al., 2021; Kang et al., 2017; Sun et al., 2024). Sleep quality declines with ageing in general, and for a portion of older adults, that may cause, contribute to, or exacerbate severity of poor SCF in SCD (Exalto et al., 2022; Jessen et al., 2020). Compared to non-SCD controls, older adults with SCD are shown to have worse subjective sleep quality and report lower quality of life (Leng et al., 2020). When comparing objective and subjective sleep quality in SCD, subjective sleep is significantly correlated with SCF scores while objective is not (Jiang et al., 2022), yet subjective sleep (e.g., PSQI) has still been demonstrated as a robust predictor of accelerated objective cognitive decline trajectories in adults over 65 with SCD (Huang et al., 2025). There appears to be a gap in the literature in terms of assessing sleep as a possible mediator between mindfulness and SCF – it remains unclear whether sleep mediates the relationship between MBI and subjective cognitive functioning.

### 3.4 The Current Study

This study aims to advance past findings by analysing RCT data on trait mindfulness, MBI, SCF, and sleep quality from the SCD-Well clinical trial (Marchant et al., 2018). The objectives and hypotheses are as follows. Objective 1 is to investigate if there is an association between trait mindfulness and SCF at baseline. We hypothesise that trait mindfulness will be associated with SCF controlling for age, education, sex, objective cognitive function, and data collection site. Objective 2 is to investigate if there are changes in SCF scores over time (baseline, 8-week post-intervention, and 24-week follow-up) for both groups (MBI vs psychoeducation) and if are there differences between the MBI vs psychoeducation groups in SCF outcome scores. We hypothesise that positive changes will occur in SCF over time, and that the MBI group will outperform the psychoeducation control group. Objective 3 is to investigate if the effect of trait mindfulness (measured by the Five Facet Mindfulness Questionnaire; FFMQ) (Baer et al., 2006) on SCF is mediated by changes in sleep quality. We hypothesise that there will be an indirect effect of intervention on follow-up SCF scores through post-intervention sleep quality scores.

## 3.5 Methods

### Design

This study is a secondary analysis of data from the SCD-Well study (Marchant et al., 2018) from the larger Medit-Ageing project. SCD-Well was an observer blinded randomized controlled trial (registered on ClinicalTrials.gov, NCT03005652) with data collected from four centres across Europe: Barcelona, Cologne, London, and Lyon, at three timepoints; baseline, post-intervention (week 8), and 6-month follow-up (24 weeks). SCD-Well was sponsored by the French National Institute of Health and Medical Research (INSERM). Ethical approval and regulatory authorizations were obtained at each centre, and written informed consent was obtained from all participants. The complete details of the study's eligibility criteria, conditions, and measures are available in the primary outcome report, which focuses on trait anxiety (Marchant et al., 2021). The experimental condition was a tailored mindfulness-based intervention (MBI) based on Mindfulness-Based Stress Reduction (MBSR) (Caring Mindfulness-based Approach for Seniors), and the control condition a health self-management education program.

## Participants

Participants were recruited from March 2017 through January 2018 by research teams on the Medit-Ageing project from memory clinics at the 4 European sites where the trial assessments and intervention delivery of took place. Participants were either referred to a memory clinic by a physician or were self-referrals. For inclusion, participants had to meet requirements specified by Marchant et al. (2021), which included criteria for subjective cognitive decline (SCD) (Ball et al., 2020), specifically, self-perceived cognitive decline and normal performance on standardised cognitive tests used to screen for mild cognitive impairment (MCI) and/or dementia. Participants were excluded if they had a current clinical diagnosis of MCI or dementia, anxiety, depression, or other psychiatric disorder. The minimum age for inclusion was 60 years. The final sample consisted of 147 older adults with SCD (mean age 72.7 ± 6.9 years; 65% female).

## Procedure

Due to the group-based nature of the interventions, participants were originally recruited in two waves at each site. Recruitment was undertaken from March 23rd 2017 to January 25th 2018 and data collection was completed by

September 18th 2018. Participants fulfilling the eligibility criteria attended a baseline visit (week 0) for cognitive and behavioural assessments and were then randomized with a 1:1 allocation using permuted block sizes of 4 and 6, and were also stratified by site. Participants met their intervention facilitator at a pre-class meeting, during which they were allocated to their trial arm. The assessments were repeated at both post-intervention (week 8) and 6-month (week 24) follow-up. The size of each intervention group ranged from 7 to 13 participants. See Marchant et al. (2021) for full protocol details.

## Intervention

### *Caring Mindfulness-based Approach for Seniors (CMBAS)*

The CMBAS intervention closely followed the procedure of MBSR, consisting of a pre-class interview, eight weekly group-based in-person sessions of 2 hours, and a half-day of meditation practice in the sixth week of the program to help consolidate learning. In addition to standard MBI practices (Crane et al., 2017), there was an emphasis on compassion-based meditation practices focusing on cultivating wholesome attitudes toward oneself and others. Additional modifications included psychoeducation designed to help participants with SCD deal more adaptively with cognitive concerns and a tendency to worry, building on earlier work by Zellner Keller et al. (2014). Participants were asked to engage in home practice for approximately 1 hour per day 6 days per week and to record whether they engaged in these practices in a diary. Home practice consisted of formal practices (e.g., following guided meditation audio recordings), as well as informal practices designed to help participants apply mindfulness skills to their daily lives (e.g., mindful eating – bringing awareness to the taste, smell, and texture of a meal).

## Active Control

### *Health Self-Management Program (HSMP)*

The HSMP followed the same format and structure as CMBAS and was matched in administration, dosage, and duration (including a half-day review with a healthy lunch and a discussion in the sixth week of the program). The intervention was based on a manual for living with chronic health conditions (Lorig et al., 2013); the manual was available in English, French, Spanish, and German. A previous RCT of an MBI which included older adults with neurocognitive difficulties adapted the manual to be delivered as a group psychoeducation intervention (Wetherell et al., 2017); the adapted program was used to equalize treatment expectancy between arms and control for the "non-specific" components of the MBI (e.g., social interaction, input from a professional facilitator and light physical activity). In the current trial, the topics taught in the HSMP included self-management, problem-solving, sleep, stress, exercise, managing medicines, communicating with family and healthcare professionals, eating, weight management, and planning for the future. To promote engagement, participants were asked to plan, undertake, and report back on weekly "action plans." Implementation of action plans was recorded by participants in a diary.

## Outcome Measures

### *Five Facet Mindfulness Questionnaire (FFMQ)*

The FFMQ (Baer et al., 2006) is a 39-item self-report measure designed to assess trait mindfulness across five theoretically derived facets: Observing (noticing sensory stimuli), Describing (labeling experiences verbally), Acting with Awareness (attending to present actions), Non-judging of Inner Experience (accepting thoughts/emotions without criticism), and Non-reactivity to Inner Experience (allowing thoughts/feelings to arise without fixation). The FFMQ and its five components were developed through factor analysis of existing mindfulness scales (Mindful Attention Awareness Scale, Freiburg Mindfulness Inventory, Kentucky Inventory of Mindfulness Skills, Cognitive and Affective Mindfulness Scale Revised, and the Southampton Mindfulness Questionnaire) and it is considered the most comprehensive mindfulness measure (Sauer et al., 2013).

Participants rate items on a 5-point Likert scale (1 = Never or very rarely true to 5 = Very often or always true). Subscale scores are computed by summing responses for each facet, with higher scores reflecting greater mindfulness. Some items are reverse scored (R). The Observing subscale comprises eight items (e.g., “I pay attention to sensations, such as the wind in my hair or sunlight on my face”, items 1, 6, 11, 15, 20, 26, 31, 36), Describing includes eight items (e.g., “I can easily put my beliefs, opinions, and expectations into words”), three of which are reverse-scored (2, 7, 12R, 16R, 22R, 27, 32, 37), Acting with Awareness contains eight reverse-scored items (e.g., “I rush through activities without being really attentive to them”, items 5R, 8R, 13R, 18R, 23R, 28R, 34R, 38R), Non-judging consists of eight reverse-scored items (e.g., “I tell myself I shouldn’t be feeling the way I’m feeling”, items 3R, 10R, 14R, 17R, 25R, 30R, 35R, 39R), and Non-reactivity includes seven items (e.g., “I watch my feelings without getting lost in them”, items 4, 9, 19, 21, 24, 29, 33).

Psychometric examinations indicate strong internal consistency across different populations from different countries (Cronbach’s α = 0.67–0.93 across subscales) (Park et al., 2013). Confirmatory factor analyses support the five-factor structure (Baer et al., 2008). The FFMQ demonstrates convergent validity with measures of psychological well-being (e.g., negative correlations with depression [r = −0.35] and anxiety [r = −0.30]) and discriminant validity against unrelated constructs (e.g., personality traits) (Baer et al., 2008). Sensitivity to MBI (e.g., MBSR, MBCT) has been established, with medium-to-large effect sizes (d = 0.47–0.91) reported in intervention studies (Carmody & Baer, 2008). For the current analysis, internal consistency analysis showed Cronbach's α = .65 for the FFMQ.

### ***McNair Cognitive Difficulties Scale (CDS)***

The CDS (McNair & Kahn, 1983) is a 39-item scale utilized for assessing subjective cognitive function (SCF) in research and clinical settings which has been shown to predict cognitive decline in older adults, and is particularly useful in studies exploring metacognition or age-related cognitive changes (Gass et al., 2021). It effectively differentiates SCF profiles in MCI and AD cohorts, though self-report sensitivity declines with advancing impairment, so it is more accurate in less impaired cohorts (Buelow et al., 2014). Participants rate items on a 5-point Likert scale (0 = never to 4 = very often), with higher total scores (range 0–156) indicating greater perceived cognitive impairment. The CDS assesses SCF across six domains: attention/concentration (e.g., "I find it hard to keep my mind on a task"), praxis (e.g., "I have trouble using tools for minor repairs"), prospective memory (e.g., "I forget appointments"), speech problems (e.g., "I have trouble thinking of object names"), memory for names (e.g., "I forget names of people I know well"), and temporal orientation (e.g., "I forget the date"). No items are reverse scored. The scale demonstrates strong internal consistency (Cronbach's α ranges from 0.72 - 0.94 across subscales) and principal components analysis found the six-factor structure accounts for 64% of variance in clinical samples (Gass et al., 2021). While scores significantly correlate with anxiety, depression, somatic preoccupation, and thought disturbance (rs range from 0.3–0.53), they show limited association with objective neuropsychological tests (Gass et al., 2021).

Subscales of the CDS were not available/utilized in our dataset for internal consistency checks. Test-retest reliability however was strong; CDS from baseline to post-intervention showed r = .82, baseline to follow-up showed r = .79, and post-intervention to follow-up showed r = .85, all $p < .001$, which aligns with previous reports of an average .77 test-retest reliability (Gass et al., 2021).

### ***Pittsburgh Sleep Quality Index (PSQI)***

The PSQI (Buysse et al., 1989) is a 19-item measure for assessing subjective sleep quality during the previous month. It has 7 subscales each scored on 0-3 scale, which yield a global PSQI score ranging from 0-21. The subscales are subjective sleep quality (e.g., "During the past month, how would you rate your sleep quality overall?"), sleep latency (e.g., "During the past month, how long (in minutes) has it usually take you to fall asleep each night?"), sleep duration (e.g., "During the past month, how many hours of actual sleep did you get at night?"), habitual sleep efficiency (e.g., "During the past month, when have you usually gone to bed at night?", "During the past month, when have you usually gotten up in the morning?"), sleep disturbances (e.g., "During the past month, how often have you had trouble sleeping because you…" – nine options given), use of sleeping medications (e.g., "During the past month, how often have you taken medicine (prescribed or over the counter) to help you sleep?"), and daytime dysfunction (e.g., "During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?"). For full scoring procedure see Buysse et al. (1989). Scores greater than five indicate the presence of sleep disturbance and scores greater than or equal to 10 may be indicate insomnia. Internal consistency in Buysse et al. (1989)'s paper was reported as Cronbach's α = .83). Cronbach α in the current study was .75.

## Covariates

### *Demographics*

For the variable of age (continuous variable), age at time of consent was used to compute mean age at baseline. Sex was a binary variable based on biological sex. The education variable corresponded to years spent in primary, secondary, and postsecondary education. Data collection site was a nominal categorical variable with 4 categories (London, Cologne, Barcelona, Lyon) and each site was recoded to separate dummy variables (binary, 0 and 1) for regression analyses with the first site acting as reference site (0).

### *Mattis Dementia Rating Scale (MDRS)*

Objective global cognition was controlled for with MDRS (Mattis, 1988) scores. The MDRS is a 36-item battery with total scores ranging from 0-144, and five subscales: Attention, Initiation/Perseveration, Construction, Conceptualization, and Memory. For Attention, participants are asked to recite strings of digits forward and to identify a target letter within in a fast reading sequence.

Initiation/Perseveration tasks included generating shopping items in 60 seconds and alternating hand movement sequences (fist, edge, palm) on command. Construction is assessed by copying intersecting pentagons and assembling match-stick designs. Conceptualization items involves determining how pictured objects are alike (e.g., "How are a banana and an orange alike?") and sorting cards by category. Memory is measured with immediate recall of a 10-word list and delayed free recall after a 15-

min filled interval. Higher scores indicate better performance on the MDRS. The MDRS has demonstrated good internal consistency (Cronbach α ≈ .8) (Pedraza et al., 2010) and previously to that, strong split half reliability (r = .9) (Gardner et al., 1981). We could not assess the measure's internal consistency in the current study as we did not have access to MDRS subscale scores.

### Statistical Analyses

In the original SCD-Well study, sample size estimates resulted in a minimum recommended sample of 128 participants, based on an expected effect size (d = .5) of 80% power and a two-sided type 1 error of 5% for the mean change across anxiety outcomes (Marchant et al., 2018). The final sample size exceeded this (*N* = 147).

Data analyses were performed in SPSS 29. Missing data were assumed missing at random, consistent with the primary analysis (Marchant et al., 2021), and were handled using the Expectation-Maximization (EM) procedure in SPSS. EM was used to estimate values for participants with incomplete data at baseline, post-intervention, and follow-up, with *n* = 19 participants missing data at two or less timepoints.

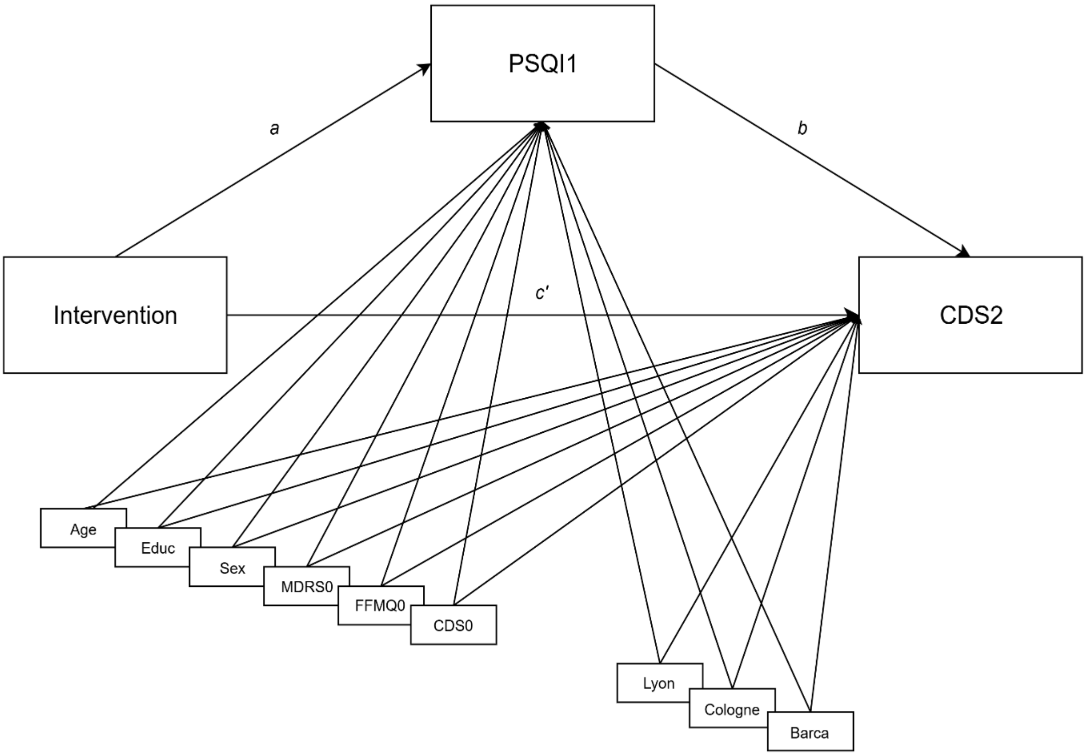
Descriptive statistics were conducted for the sample's demographic and baseline characteristics. Hierarchical multiple regression analysis was used to address the first research objective. The criterion variable was SCF (scores on the CDS). The main predictor variable was trait mindfulness (FFMQ), entered in block two, while age, education, sex, objective cognitive function, and Data Collection Site were included as predictors to control for in block one – as well as to assess their contribution to explaining the variance in the outcome. Data Collection Site was controlled for through the inclusion of three dummy variables in the regression model. This involved recoding the Data Collection Site variable into three separate variables for Lyon, Cologne, and Barcelona, while London acted as the referent. Standardised coefficients (Beta) and partial correlation coefficients were examined to interpret strength and direction of associations between predictors, the outcome of interest, and unique contribution to the regression model. Normality, multicollinearity, and homoscedasticity were checked through VIF and tolerance scores and normality plots to ensure assumptions of multiple regression were not violated.

To address Objective Two, a mixed between-within repeated measures ANOVA was conducted. The between-subjects variable was intervention which had two groups: MBI (CMBAS) and health psychoeducation (HSMP). The three measurement points served as the within-subjects variable (time) and the dependent variable was SCF (CDS). Homogeneity of intercorrelations and variance were checked using Box's M statistic and Levene's test for equality of variances, and sphericity checked with Mauchly's Test of Sphericity. Alpha was set at $< 0.05$ for all analyses.

To address Objective Three, a single-mediator mediation analysis was conducted using PROCESS v4.2 in IBM SPSS 29 (Hayes & Little, 2022). PROCESS is a regression-based mediation framework allowing researchers to test for different effect modifiers within SPSS software. To check assumptions, Q-Q plots (normality), scatterplot of outcome residuals against predictor (heteroscedasticity), and a correlation matrix (multicollinearity) were generated. Model 4 was selected to test the indirect effect of intervention group on SCF through sleep quality. The independent variable (X) was Intervention (0 = psychoeducation control, 1 = MBI), the mediator (M) was sleep quality (measured by PSQI) at post-intervention (8-weeks), and the outcome (Y) was SCF (measured by CDS) at follow-up (24-weeks). As per standard guidance on mediation analysis (MacKinnon et al., 2007) the X→M path is termed the *a* path and M→Y termed the b path. The *c'* path refers to the direct effect of X→Y. We calculated the indirect effect by multiplying the coefficients of paths a and b. Also calculated in Model 4 is the total effect, *c*, the sum of the direct and indirect effects, $(a * b) + c'$. Bootstrapping was used to repeatedly draw random samples from the data to estimate indirect effects and confidence intervals, and was set to 5,000 resamples. Covariates of age, sex, education, baseline SCF, baseline trait mindfulness, and baseline objective cognitive function were included, as well as three dummy variables for Data Collections Sites (Lyon, Cologne, Barcelona, London labelled as referent). See Figure 3.1 for diagram of proposed mediation model. Alpha was set at $< 0.05$ for all analyses. Mediation significance was determined by indirect effect confidence intervals including or excluding zero (exclusion indicates significance).

**Figure 3.1**

*Mediation Model with paths a, b, and c', and covariates*



*Note*. Intervention = independent variable (X); PSQI1 = mediator (M) Pittsburgh Sleep Quality Index post-intervention; CDS2 = outcome (Y) McNair Cognitive Difficulties Scale follow-up; *a* = X→M; *b* = M→Y; *c′* = X→Y. Covariates: MDRS0 = Mattis Dementia Rating Scale baseline; FFMQ0 = Five Facet Mindfulness Questionnaire baseline; CDS0 = McNair Cognitive Difficulties Scale baseline.

## 3.6 Results

### Descriptives

Data collection took place between January 25th - September 18th, 2018. Participants with SCD (mean age 72.7 ± 6.9 years; 65% female; see Table 3.1) were randomized into the two groups. See Marchant et al. (2021) for the participant

CONSORT flow diagram outlining the participant recruitment procedure. As would be expected, the intervention groups (CMBAS and HSMP) were not significantly different on demographic characteristics or baseline outcome measures. The mean sessions attended by participants was similar in both intervention groups (CMBAS = 6.7 [SD 2.8], HSMP = 6.8 [SD 2.7], out of a possible 9), while the percentage of participants who attended at least four sessions – the minimum requirement for intervention analysis – was 85% (CMBAS = 82%; HSMP = 87%). There were no significant group differences between continued practice rates at follow-up (CMBAS = 59%, HSMP = 54%, $p = .6$). No significant group differences were reported on credibility (CMBAS = 5.9 [SD 2.2] vs HSMP = 5.3 [SD 1.9]) or expectancy ratings (CMBAS = 4.5 [SD 1.9] vs. HSMP = 4.1 [SD 1.8]). The SCF outcome (CDS) at baseline was distributed normally (see Figure in Appendix D).

**Table 3.1**

*Descriptive Statistics*

| Variable | Total sample (n=147) | CMBAS (n=73) | HSMP (n=74) |
|---|---|---|---|
| Sex | | | |
| Female | 95 (65%) | 47 (64%) | 48 (65%) |
| Age (years) | 72.7±6.9 | 72.1±7.6 | 73.3±6.2 |
| Education (years) | 13.6±3.6 | 13.8±3.8 | 13.4±3.4 |
| Ethnicity | | | |
| White | 142 (97%) | 69 (94%) | 73 (99%) |
| Data Collection Site | | | |
| London | 28 (19%) | 14 (19%) | 14 (19%) |
| Lyon | 40 (27%) | 20 (27%) | 20 (27%) |
| Cologne | 39 (26%) | 19 (26%) | 20 (27%) |
| Barcelona | 40 (27%) | 20 (27%) | 20 (27%) |

*Note.* CMBAS = Caring Mindfulness-Based Approach for Seniors, HSMP = Health Self Management Program. Data presented as means with SD (±), or totals with percentage (%).

## Objective 1

A hierarchical multiple regression was conducted to assess the association between trait mindfulness (FFMQ scores) and SCF (CDS scores) among older adults with SCD, while controlling for age, education, sex, and global objective cognitive performance (Mattis Dementia Rating Scale; MDRS), and data collection site. Collinearity statistics indicated acceptable tolerance ($\geq .42$) and VIF ($\leq 2.39$) values. In Step 1, control variables were entered, producing a significant model, $F(7, 139) = 3.552$, $p = .002$, explaining 15.2% of CDS variance (adjusted $R^2 = .11$). In Step 2, trait mindfulness (FFMQ) was added, significantly improving the model fit, $R^2$ change = .14, $F$ change $(1, 138) = 27.24$, $p < .001$. The final model was significant, $F(8, 138) = 7.10$, $p < .001$, explaining 29.2% of CDS variance (adjusted $R^2 = .25$). In the final model, trait mindfulness was the strongest predictor ($\beta = -.40$, $p < .001$), with higher trait mindfulness associated with better (decreased) CDS scores ($B = -1.14$, 95% CI [-1.57, -.71]). Age remained a significant predictor ($\beta = .212$, $p = .006$, 95% CI [.18, 1.08]). Data collection site significantly influenced outcomes, with all three international sites reporting fewer cognitive complaints than the reference site (London): Lyon ($\beta = -.38$, $p < .001$; $B = -17.57$, 95% CI [-27.64, -7.49]), Cologne ($\beta = -.27$, $p = .01$; $B = -12.364$, 95% CI [-21.80, -2.93]), and Barcelona ($\beta = -.247$, $p = .02$; $B = -11.35$, 95% CI [-20.58, -2.13]). Years of education ($\beta = -.13$, $p = .09$; $B = -.74$, 95% CI [-1.60, .12]), sex ($\beta = .10$, $p = .20$; $B = 4.41$, 95% CI [-2.36, 11.20]) and global objective cognitive performance ($\beta = .14$, $p = .11$; $B = .78$, 95% CI [-.18, 1.74]) were not significant predictors in the final model.

**Table 3.2**

*Hierarchical multiple regression of baseline subjective cognitive function on baseline trait mindfulness*

| Variable | $R^2$ | $R^2$ *Change* | *B* | *SE* | *β* | *95% CI Lower, Upper* | *p* |
|---|---|---|---|---|---|---|---|
| **Block 1** | | | | | | | |
| Model | .15 | | | | | | .002* |
| Sex | | | 5.34 | 3.74 | .13 | -2.05, 12.73 | .16 |
| Age | | | .63 | .25 | .21 | .13, 1.12 | .01* |
| Educ (years) | | | -1.19 | .47 | -.21 | -2.11, -.27 | .01* |
| MDRS | | | .48 | .52 | .08 | -.58, 1.51 | .36 |
| Lyon site | | | -14 | 5.50 | -.31 | -24.88, -3.11 | .01* |
| Cologne site | | | -12.58 | 5.20 | -.27 | -22.89, -2.30 | .02* |
| Barcelona site | | | -9.71 | 5.08 | -.21 | -19.75, .33 | .06 |
| **Block 2** | | | | | | | |
| Model | .29 | .14 | | | | | <.001* |
| Sex | | | 4.41 | 3.43 | .10 | -2.38, 11.20 | .20 |
| Age | | | .63 | .23 | .21 | .18, 1.08 | .006* |
| Educ (years) | | | -.74 | .44 | -.13 | -1.60, .13 | .09 |
| MDRS | | | .78 | .48 | .14 | -.18, 1.74 | .11 |
| Lyon site | | | -17.6 | 5.10 | -.38 | -27.64, -7.45 | <.001* |
| Cologne site | | | -12.36 | 4.77 | -.27 | -21.80, -2.93 | .01* |
| Barcelona site | | | -11.53 | 4.67 | -.25 | -20.58, -2.13 | .02* |
| FFMQ | | | -1.14 | .22 | -.40 | -1.58, -.71 | <.001* |

*Note*. * indicates significance. FFMQ = Five Facet Mindfulness Questionnaire, MDRS = Mattis Dementia Rating Scale, Educ = Education. Lyon, Cologne, Barcelona sites are dummy coded with London as reference site.

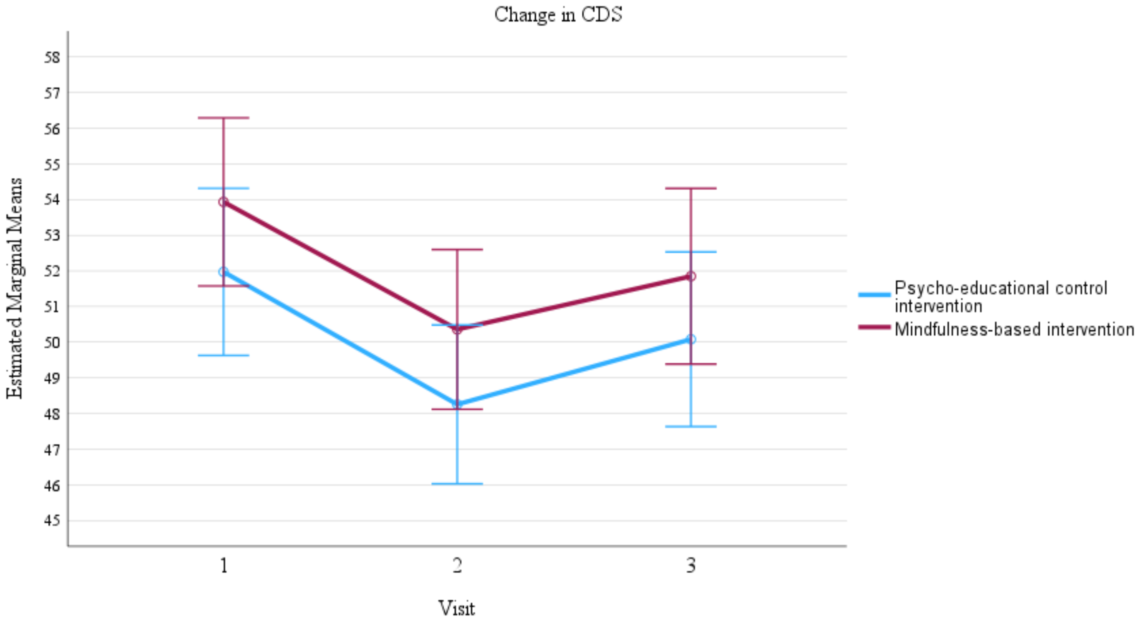
**Objective 2**

A mixed between-within subjects analysis of variance examined the effects of time and intervention arm (MBI vs. psychoeducation) on CDS scores over three timepoints. Data Collection Site (London, Lyon, Cologne, Barcelona) was controlled for. Mauchly's test indicated no violation of sphericity, $\chi^2(2) = 5.87$, $p = .08$. A significant, small-medium main effect of time was found, $F$ (2, 278) = 6.23, $p = .002$, partial eta squared = .04, with pairwise contrasts showing significant differences between Time 1 (week 0) vs Time 2 (week 8); ($F$ (1,139) = 13.08, $p < .001$) but not Time 2 vs Time 3 (week 24); ($F$ (1,139) = 3.01, $p = .08$). As illustrated in Figure 3.2, values of CDS were lower at time 2 (week 8) than time 1 (week 0) and remained stable at time 3 (week 24). No significant interactions were found between time and intervention ($F$ (2, 278) = 0.01, $p = .99$), time and site ($F$ (6, 278) = 0.73, $p = .56$), or the three-way time×intervention×site interaction ($F$ (6, 278) = 0.78, $p = .59$).

Between-subjects effects revealed a significant main effect of site, $F$ (3,139) = 3.30, $p = .02$, partial eta squared = .07, but no significant main effect of intervention ($F$ (1,139) = 0.39, $p = .53$) or intervention×site interaction ($F$ (3,139) = 2.03, $p = .11$). London participants consistently had the highest CDS scores across timepoints (M = 61.35 at Time 1, 58.79 at Time 2, 60.57 at Time 3), while Cologne showed the lowest initial scores (M = 48.29 at Time 1).

**Figure 3.2**

*ANOVA plot*



*Note.* 1 = baseline, 2 = 8-weeks, 3 = 24-weeks. CDS = McNair cognitive difficulties scale. Error bars +/- 1 standard error.

### Objective 3

A mediation analysis was conducted with PROCESS Model 4 to investigate whether sleep quality at post-intervention (PSQI1) mediated the effect of intervention (Int) on SCF at follow-up (CDS2). Q-Q plots of PSQI1 and CDS2, scatterplot of residuals, and correlation matrix showed no violation of assumptions of linearity, homoscedasticity, and multicollinearity (see Appendix E and F).

Model 4 (Appendix G) showed the indirect effect's upper and lower limit confidence intervals (ULCI; LLCI) crossed zero; there was no significant unstandardised effect of intervention on SCF through sleep quality (*ab* = -.05, SE = .28, LLCI = -.64, ULCI = .55). Both the unstandardised total effect (*c* = .75, SE =

2.09, *p* = .72) and direct effect (*c′* = .80, SE = 2.10, *p* = .71) of intervention on SCF were non-significant.

In the mediator (PSQI1) model (R = .45, $R^2$ = .20, *F*(10,136) = 3.47, *p* < .001), the *a* path (Int→PSQI1) was not significant after controlling for covariates (B = .45, SE = .55, t = .81, *p* = .42). Significant covariates in the mediator model included age (B = .10, SE = .04, *p* = .02) and baseline SCF (CDS0; B = .06, SE = .02, *p* < .001), while other covariates were not significant.

In the outcome (CDS2) model (R = .83, $R^2$ = .68, *F*(11,135) = 26.17, *p* < .001), the *b* path (PSQI1→CDS2) was not significant (B = -.11, SE = 0.33, t = -.33, *p* = .74). Significant covariates in the outcome model included baseline SCF (CDS0; B = .72, SE = .06, *p* < .001) and baseline trait mindfulness (FFMQ0; B = -.42, SE = .17, *p* = .01), while age trended towards significance (B = .31, SE = .17, *p* = .06). All other covariates were nonsignificant. Results including standardised beta scores (β) are presented in Table 3.3 and Figure 3.3.

**Table 3.3**

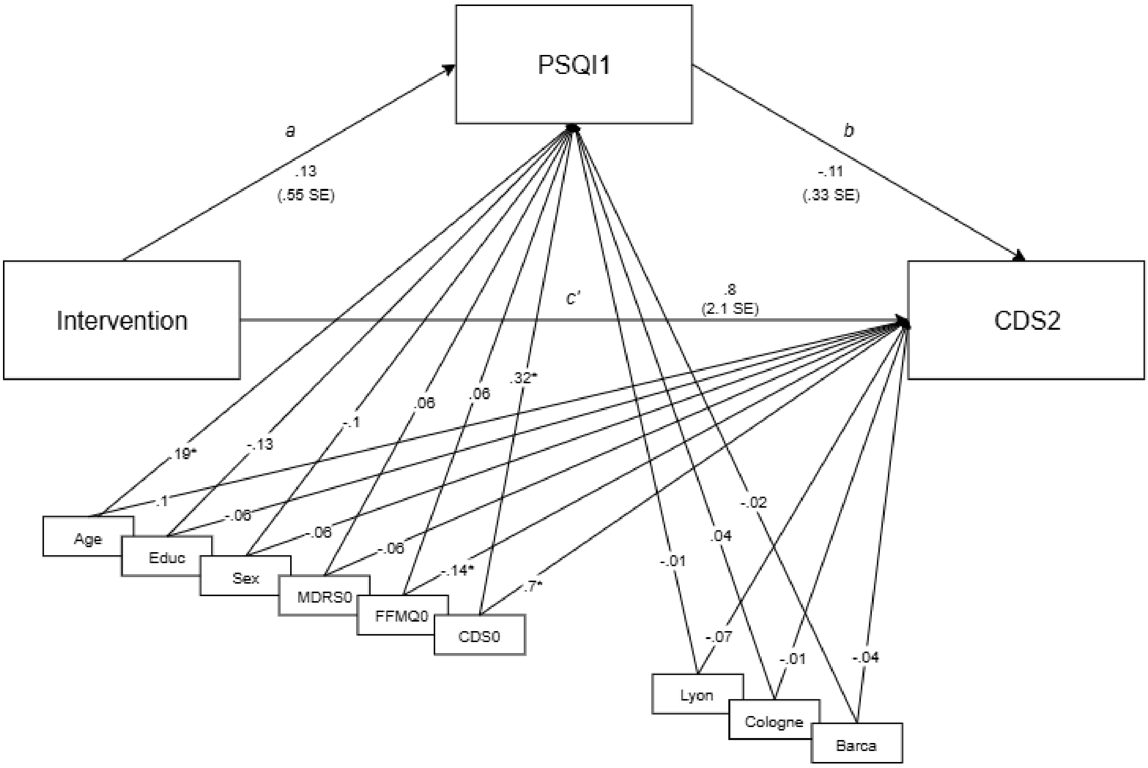
*Mediation results*

| **Path/Model** | **B** | **β** | **SE/ BootSE** | **95% CI LL** | **95% CI UL** | **t** | **p** | **$R^2$** | **F (df1, df2)** |
|---|---|---|---|---|---|---|---|---|---|
| *a* | .45 | .13 | .55 | -.64 | 1.54 | | .42 | | |
| *b* | -.11 | -.02 | .33 | -.75 | .54 | | .74 | | |
| *c* (total) | .75 | .04 | 2.09 | -3.39 | 4.88 | .36 | .72 | | |
| *c′* (direct) | .80 | .04 | 2.10 | -3.36 | 4.95 | .38 | .71 | | |
| *ab* (indirect) | -.05 | .00 | .28 | -.64 | .55 | | | | |
| PSQI1 model | | | 10.76 | | | | .00* | .20 | 3.47 (10, 136) |
| CDS2 model | | | 156.03 | | | | .00* | .68 | 26.17 (11, 135) |

*Note*. PSQI1 = Pittsburgh Sleep Quality Index post-intervention (mediator); CDS2 = McNair Cognitive Difficulties Scale follow-up (outcome); Int = Intervention; *a* path = Int → PSQI1; *b* path = PSQI1 → CDS2; *c* path (total) = Int → CDS2 excluding PSQI1; *c'* path (direct) = Int → CDS2 controlling for PSQI1; *ab* (indirect) = Int → PSQI1 → CDS2; * indicates significance.

**Figure 3.3**

*Mediation model with standardised coefficients*



*Note.* Intervention = independent variable (X); PSQI1 = mediator (M) Pittsburgh Sleep Quality Index post-intervention; CDS2 = outcome (Y) McNair Cognitive Difficulties Scale follow-up; *a* = X→M; *b* = M→Y; *c'* = X→Y. Covariates: MDRS0 = Mattis Dementia Rating Scale baseline; FFMQ0 = Five Facet Mindfulness Questionnaire baseline; CDS0 = McNair Cognitive Difficulties Scale baseline.

* indicates significance.

## 3.7 Discussion

This secondary analysis of SCD-Well clinical trial data aimed to assess the associations between mindfulness (operationalised both as a trait and experimentally via the delivery of an intervention) and subjective cognitive function (SCF) among a group of older adults with subjective cognitive decline (SCD). The first objective was to examine the association between trait mindfulness and SCF controlling for covariates. Baseline data showed trait mindfulness was significantly negatively associated with SCF (greater mindfulness associated with better SCF), and that it was a stronger predictor of SCF than any covariate. For every one-unit increase in trait mindfulness, there was a corresponding 1.11 improvement in SCF. Increased baseline age was associated with worse sleep quality, but was not related to SCF. Data collection site also had an association with SCF as an outcome. Although not the focal point of this study, these findings suggest geographical/cultural differences may exist in SCD. The second objective was to investigate changes in SCF over time, examining within- and between-group differences across baseline, post-intervention (8-weeks), and follow-up (24-weeks), and between the experimental and control groups. Similar improvements occurred in SCF over time in both the experimental (mindfulness-based intervention [MBI]) and active control (psychoeducation) groups, particularly at post-intervention. Specifically, both groups showed a small to medium improvement in SCF scores from baseline to post-intervention. There was a slight worsening of SCF in both groups at 6-month follow-up compared to post-intervention levels. Between groups, MBI was not superior to psychoeducation for improving SCF at post-intervention or follow-up. The third objective was to investigate sleep quality as a mediator between intervention and SCF, controlling for demographics, trait mindfulness, objective cognitive function, baseline SCF, and data collection site. Findings showed no indirect (mediation) effect of MBI on SCF through sleep quality, nor was there a direct effect of MBI on SCF. MBI did not significantly improve post-intervention sleep quality, and sleep quality did not significantly improve SCF at follow-up when modelled with covariates. It is important to acknowledge that a mediation effect can still occur even when the overall effect of MBI on SCF is not significant, for example in the case of a suppressing mediating effect, where other mediators not controlled for counteract and potentially cancel out any mediating effect of sleep quality (MacKinnon et al., 2007).

Our first hypothesis, that trait mindfulness would be associated with SCF, was supported by our findings. Results align with recent cross-sectional research on trait mindfulness and SCF (MacAulay et al., 2022). Psychologically, high trait mindfulness may reduce cognitive concerns/worries in SCF, as has been demonstrated in research on older adults with SCD and in similar populations, such as older adults with MCI (Lenze et al., 2014), cognitively healthy older adults (Franco et al., 2017), and older adults at risk of dementia due to family history (Strikwerda-Brown et al., 2021). Increased worry in SCD is also linked to higher levels of Alzheimer's disease (AD)-like brain pathology, especially in the default mode network (DMN), a network of brain regions associated with susceptibility to mind-wandering and maladaptive thinking patterns (Lim et al., 2019; Verfaillie et al., 2019). Neurologically, increased trait mindfulness may improve SCF by targeting worry-associated brain regions in SCD; a series of studies have shown trait mindfulness is linked to better DMN function in older adult populations (Brewer, Worhunsky, et al., 2011; Ganesan et al., 2023; Hasenkamp & Barsalou, 2012; Shaurya Prakash et al., 2013) as well as less dementia-related pathology like amyloid/tau deposition and white/grey matter atrophy (Pernet et al., 2021; Strikwerda-Brown et al., 2021; Tang et al., 2019). Mindfulness targeting SCF in this way fits with the Mindfulness-to-Meaning Theory proposing that increased non-judgmental awareness improves cognitive reappraisal capacity (Garland et al., 2015; Garland et al., 2017), and this improvement may be related to the aforementioned worry-associated pathology (Verfaillie et al., 2019) .

Contrastingly to our results, Brisbon and Lachman (2017) found that trait mindfulness did not directly impact SCF, but impacted SCF indirectly through perceived stress, suggesting SCF could be confounded with subjective stress levels. Yet trait mindfulness ameliorating either subjective cognitive ability or subjective stress levels still indicates benefits for reducing cognitive decline rates, e.g., stress-buffering model (MacAulay et al., 2023). However, Brisbon and Lachman's (2017) study only measured subjective memory, so findings might not transfer to general SCF or subjective worry, the dimension of SCD that trait mindfulness could be most useful for targeting. Perceived stress, the variable that mediated Brisbon and Lachman's (2017) findings, may also be conflated with worry/concerns in SCD. In future, research using consistent measures of SCF and clear SCD criteria should improve study homogeneity. Additionally, to the best of our knowledge, only one extant study controlled for potentially confounding personality traits while investigating trait mindfulness implications in SCD (Strikwerda-Brown et al., 2021). It is therefore possible that baseline associations between trait mindfulness and SCF could be due to personality traits that more mindful individuals tend to share, particularly low neuroticism/emotionality, which research has shown to be higher with poor SCF (Aschwanden et al., 2022; Zullo et al., 2021) and lower with high trait mindfulness (Giluk, 2009; Hanley, 2016). Future work should ideally measure personality (e.g., Big Five) to control for or to investigate personality traits' roles in the trait mindfulness-SCD relationship.

Our second hypothesis was that positive changes would occur in SCF from baseline to post-intervention to 6-month follow-up in both groups, and further, that the MBI group would outperform the psychoeducation control group on a measure of SCF (CDS). There was a significant small-medium sized main effect of time, mostly contributed to by significant change from baseline to post-intervention, while there was no further significant change from post-intervention to follow-up, so the first part of our hypothesis was supported. However, there were no significant differences in SCF between the MBI group and the psychoeducation group. There was no significant interaction between time and intervention type, with both groups' SCF improving equivalently over time when controlling for four data collection sites and covariates. This finding extends results from other SCD-Well trial studies which found MBI and psychoeducation equivalent in improving anxiety and objective cognitive outcomes (Marchant et al., 2021; Whitfield et al., 2022). Smart and colleagues' (2016) pilot trial also found mostly equivalent improvements in objective cognitive function between MBI and psychoeducation conditions. However, MBI participants with SCD showed improvement in SCF and greater ability in moment-to-moment task reaction (Go/Nogo task) and P3 amplitude (neural marker of attentional capacity), suggesting underlying changes may be caused by MBI. A meta-analysis and systematic review supports psychoeducation as effective for those with SCD (Roheger et al., 2021), though evidence primarily focused on objective cognitive outcomes, and only the aforementioned study (Smart et al., 2016) compared psychoeducation to standardised MBI within the meta-analysis. While MBI and psychoeducation both appear effective for reducing SCF in SCD, MBI may have distinct neurological benefits that warrant further investigation into neuroimaging measures' association with SCF. Future research should build on Smart and colleagues' (2016) study and compare MBI to psychoeducation for those with SCD in larger samples, using neuroimaging outcomes to determine if MBI leads to distinct neural changes associated with change in SCF outcomes.

Data collection site was controlled for in our analysis for Objective 2, and interesting results emerged. Analysis revealed London participants had worse SCF than Cologne, Barcelona, and Lyon at all time points. Increased urbanization is linked to worse health outcomes that may influence SCF (e.g., stress, anxiety, depression, sleep quality), and with London being one of the most urbanized cities in the world and more population-dense than Cologne, Barcelona, and Lyon, this may explain this geographical difference in the data (Baumann & Brooks-Cederqvist, 2023). Baumann and Brooks-Cederqvist (2023) showed that individuals in lower density, less urban environments exhibit higher levels of EEG theta activity in the brain, a state of electrical brain activity that is also induced by mindfulness practice (Tang et al., 2019). It may be more challenging for individuals in higher density locations to achieve the ideal state of theta brain activity when practicing mindfulness as their theta activity levels are lower to begin with. Smart and colleagues' (2016) findings agree with this notion – MBI significantly improved the P3 component of EEG, which measures theta activity and indicates improved cognitive control (Harper et al., 2014; Pscherer et al., 2022). Another element to consider is social engagement. Social engagement has been consistently linked to improved objective cognitive and psychological outcomes in older adults (Kelly et al., 2017; Krueger et al., 2009; Monteiro et al., 2024; Saha et al., 2024), which may translate to SCF. Here, social interaction was indeed matched in MBI and control conditions, so social engagement could underly and explain the similar changes observed from MBI and psychoeducation, potentially driving outcomes in SCD more than specific MBI or psychoeducation protocol elements. Furthermore, Livingston et al. (2024), in their Lancet report on dementia prevention, list social engagement/isolation as one key factor of 14 that contributes to dementia development by impacting brain health and cognitive reserve. An important direction for future research should be to disentangle the effects of social engagement/isolation from intervention-specific elements to better understand how MBI and psychoeducation drive improvements in SCF.

Our third hypothesis was that sleep quality would mediate the relationship between MBI and SCF. Findings did not support sleep quality as a mediator, with baseline SCF being the strongest predictor of SCF at follow-up, while trait mindfulness also had a significant small effect on SCF at follow-up. The lack of significant effect in path *a* (Intervention→PSQI1) is contradictory to previous research showing that MBI can improve sleep quality in healthy older adults (Black et al., 2015; Gallegos et al., 2018; Zhang et al., 2015), including our meta-analysis in Ch2 (H2) (Lannon-Boran et al., 2023). This discrepancy could be due to the fact that most studies on older adults that investigate sleep quality and mindfulness recruit participants with poor sleep quality, sleep disturbance, or insomnia (Garland et al., 2016; Gong et al., 2016; Kanen et al., 2015; Li et al., 2025). Our sample was not selected for having poor sleep quality; mean baseline PSQI scores indicated some participants had mild sleep issues. There may have been a ceiling effect with limited room for improvement in sleep in our sample (Youngstedt, 2003). The nonsignificant *b* path (PSQI1→CDS2) is surprising given cross-sectional studies have consistently found association between sleep quality and SCF levels in SCD (Exalto et al., 2022;

Jiang et al., 2022; Siddarth et al., 2021; Sun et al., 2024). However, longitudinal or RCT studies investigating sleep quality's effect on SCF are scant, so the direction of the sleep-SCF relationship is uncertain. Our analysis showed a medium-sized effect of baseline SCF on sleep quality at post-intervention, so it's possible that cross-sectional studies are showing that poor SCF (e.g., increased self-reported concern, worry, about cognitive function) drives sleep quality down rather than vice versa – thus, sleep mediation pathways may be more complex than cross-sectional research suggests.

The lack of mediation effect (*ab* path) has several possible explanations. The fact that baseline SCF accounted for much of the variance in follow-up SCF is a reflection of the lack of change in SCF from MBI through sleep quality. The MBI may have been too short in duration to cause meaningful changes in sleep quality compared to psychoeducation, or to cause meaningful changes in the mechanisms of combined improvement of acceptance and awareness, theorized to be required for improvements in health outcomes from MBI (MAT theory) (Lindsay & Creswell, 2017; Shallcross et al, 2019). It would be beneficial to evaluate longer duration MBI effects on healthy older adults where effects may be more subtle or preventative of, for example, sleep decrements typical in ageing, or progression of cognitive impairment in healthy yet at-risk populations such as SCD (Whitfield et al., 2022) . Subjective measures of sleep quality and cognitive function also may not be sensitive enough to detect change in older adults without moderate-strong sleep issues (Landry et al., 2015) and without cognitive impairment (Pavel et al., 2022). If this is the case, objective sleep measures may yield different mediation results in those with SCD, e.g., use of actigraphy or polysomnography in place of self-report sleep measures. That said, study findings disagree on subjective (Jiang et al., 2022) and objective sleep (Lauriola et al., 2016) associations with SCD, suggesting further research is required to ascertain which measures are optimal, or, as suggested by Landry et al. (2015), both objective and subjective sleep measures be used when participants are unimpaired. As the criteria for SCD requires objective cognitive test scores within normal ranges, and since SCF may be more sensitive to underlying neuropathological decline than objective measurement (Sharma et al., 2019; Stewart et al., 2011), neuroimaging outcomes may be preferable over objective or subjective outcomes to detect meaningful change in older adults with SCD. On the other hand, Pavel et al. (2022) found subtle but detectable differences in objective cognitive ability (although still within normal ranges) between SCD and non-SCD older adults, and suggest further defining SCD progression; earlier SCD having no objective impairment, and later SCD showing subtle objective decline comparatively. Recent work on defining SCD has indeed introduced such a criteria ("SCD plus"), based mostly on the presence of dementia-related biomarkers from neuroimaging alongside SCD (Kuhn et al., 2025), but additionally, this group seem to perform worse within normal ranges of objective cognitive measures (Monisha et al., 2025). Future work should also then investigate MBI and sleep quality in this SCD group with subtle objective decline and/or early markers of dementia.

As mentioned, Pavel and colleagues (2022) and other studies (Aschwanden et al., 2022; Zullo et al., 2021), observed the strong association of the neurotic personality trait in SCD, a potential confounder we could not control for in our mediation analysis. Expanding on this, Aschwanden et al. (2022) suggest that lower neuroticism, which is associated with high trait mindfulness (Giluk, 2009; Hanley, 2016), may indicate a more "resilient" personality, where these individuals have greater cognitive reserve that maintains subjective and objective cognitive functioning. Interestingly, a review postulates that mindfulness enhances cognitive reserve (Malinowski & Shalamanova, 2017). This could explain our finding that baseline trait mindfulness predicted better SCF at follow-up, even while controlling for baseline SCF, demographics, and objective cognitive function. Combined with findings from our first objective that baseline trait mindfulness predicts baseline SCF, this finding could be an indication that individuals with innately higher mindfulness are better positioned to maintain good SCF, but did not benefit additionally from undergoing MBI. It may also indicate that trait mindfulness is a more stable trait than thought, that again, may need longer periods of practice or intervention for there to be meaningful change that leads to improved sleep quality, and then improved SCF, reducing risk of future cognitive impairment. Future research should strive to control for or investigate directly the role of personality traits when studying sleep quality's relationship to SCF, and clarify the impact lengthened MBI has on sleep and SCF through promoting trait mindfulness.

### 3.7.1 Strengths and Limitations

There were a number of strengths to this study. Participants were randomized to experimental and active control groups and the sample size was large in comparison to previous MBI studies on SCD (Smart et al., 2016; Wetherell et al., 2017). Data was collected from four locations across Europe, making findings more generalisable across European older adult populations. Participants were all aged over 60, recruited from memory clinics, and fit within standardised criteria for SCD. This increased the homogeneity of the sample and targeted cognitively unimpaired individuals who were at risk of dementia. The sample were also distinct from cognitively healthy older adults and those with MCI or with psychiatric or neurodegenerative disorders. The MBI used (CMBAS) closely followed standardised

MBSR protocol for easier replicability in future work and comparison with extant work (Lenze et al., 2014; Smart et al., 2016; Wetherell et al., 2017). Marchant and colleagues' (2021) choice of MBI and control condition was also based on recommendations for RCTs of psychological interventions (Guidi et al., 2018). There was the same amount of facilitator contact time in each condition, blinded outcome raters, and a 6-month follow-up measurement point – increasing intervention fidelity, minimizing bias, and thus improving validity of the research for translation to real-world settings and future replication or homogeneity in meta-analysis. In our mediation analysis, we were able to control for numerous relevant covariates, and our mediator variable for sleep quality was a widely used sleep quality measure (PSQI), allowing for comparison with past research in SCD and sleep quality, as well as making homogeneity easier in future studies examining sleep and SCD severity.

While the active psychoeducation control and 6-month follow-up were strengths, the lack of a passive waitlist group and further follow-ups were limitations. The absence of a passive control meant it was not possible to tell if changes in SCF were definitely due to elements of MBI or psychoeducation, and follow-up was too short to ascertain cognitive trajectories of progression or non-progression to cognitive impairment or dementia, or longer-term change in SCF. Issues with SCF measurement heterogeneity have recently been highlighted in the literature (Jessen et al., 2020; Pavel et al., 2022), and our measure of SCF (CDS) did differ from many extant studies which assessed SCD severity with other measures of SCF (e.g., Smart et al., 2016; Strikwerda-Brown et al., 2021; Wetherell et al., 2017); this should be addressed in the future to achieve better homogeneity across studies. As SCF is a self-report measure, it is therefore subject to introducing measurement bias as well, making the aim of increased SCF measurement homogeneity even more important. Finally, different underlying causes of SCD may exist (e.g., neurological causes, psychological causes, personality differences) which could not be controlled for in this study and therefore may have impacted results.

### 3.7.2 Conclusions and Key Implications

This secondary analysis of SCD-Well trial data found that higher trait mindfulness is significantly associated with better SCF in older adults with SCD, independent of age, education, objective cognitive function, and data collection location (Objective 1). This finding highlights the potential protective role of trait mindfulness in SCD, suggesting that promoting trait mindfulness could help buffer against cognitive concerns measured by SCF. However, both the MBI and the psychoeducation condition showed similar improvements in SCF post-intervention, and 6-month follow-up (Objective 2). While both interventions may be beneficial for SCF, MBI does not appear to be superior to psychoeducation in this context, but the independent associations between baseline trait mindfulness and better SCF at both baseline (Objective 1) and follow-up (Objective 3) implies that individuals with lower trait mindfulness might benefit more from targeted mindfulness interventions, while others may achieve comparable improvement through psychoeducation. Mediation analysis (Objective 3) showed that, in our sample, post-intervention sleep quality did not mediate the effect of MBI or psychoeducation on SCF at follow-up; the findings of interest from Objective 3 were that baseline SCF and baseline trait mindfulness predicted follow-up SCF, while baseline SCF also predicted post-intervention sleep quality. Lengthened MBI duration should be considered in future, as well as sleep and cognitive measurement sensitivity in older cognitively unimpaired adults who don’t have sleep issues, but are still at-risk due to SCD status.

Those with SCD as well as subtle objective cognitive decrements and sleep difficulties may benefit more from interventions aimed at improving sleep and SCF. Alternatively, studies in SCD should focus on prevention of sleep disturbance and cognitive decline to reduce cognitive impairment progression risk.

Notably, geographical differences in SCF outcomes were observed, indicating that environmental or cultural factors may also play a role. Geographical differences may impact the efficacy of MBI due to mindfulness effects on theta wave brain activity in SCD (Smart et al., 2016) and reduced theta wave activity in highly urban areas (Baumann & Brooks-Cederqvist, 2023). Disentangling these relationships will be useful for advancing our understanding of the interconnections between mindfulness, environment, and SCD. Future studies should also examine socio-cultural and lifestyle factors that may influence SCF, sleep quality, and trait mindfulness in this population. Overlapping cognitive reserve factors such as social engagement, occupational complexity, bilingualism, and physical activity may have influenced the current findings, and warrant inclusion in future studies (Livingston et al., 2020; Stern et al., 2020). Additionally, given that the present sample was largely female, menopause represents a possible important variable. Menopause is associated with disrupted sleep, worse SCF, and increased vulnerability to low mood and anxiety, factors which may impact trait mindfulness and even confound with SCD criteria (Maki & Henderson, 2016). Future research should include menopause status, or add it as a covariate, to better understand these effects. Finally, research into those with low trait mindfulness and SCD, as well as mindfulness (trait and intervention) and different SCD etiologies (e.g., SCD, SCD plus) is warranted. MBI may have a stronger impact on SCD stemming from causes that mindfulness more strongly targets, for example, the AD-related pathology in those with SCD plus.

Future research should ideally include a passive control and longer follow-up periods with this group to determine whether SCF improvements can offset or buffer against progression of pathological cognitive decline.

# Chapter 4: General Discussion

## 4.1 Introduction

Interventions or lifestyle changes are best implemented early when individuals are at higher risk of developing dementia but before onset of objective cognitive impairment; “the earlier, the better” (Livingston et al., 2024, p. 572). The overarching aim of this thesis was to determine whether MBI as a non-pharmacological intervention, or trait mindfulness, could serve to support healthy cognitive ageing, directly or through sleep quality, and thus potentially mitigate dementia risk. This thesis examined relationships between mindfulness (trait mindfulness and mindfulness-based intervention; MBI), sleep quality, and objective and subjective cognitive function (SCF). We examined these associations in cognitively healthy older adults more broadly and then in (objectively) cognitively healthy older adults with subjective cognitive decline (SCD). Two interconnected studies addressed this aim through distinct but complementary designs: a systematic review and meta-analysis of randomized controlled trials (RCT) investigating MBI effects on objective cognitive function and sleep quality in healthy older adults (Chapter 2; Ch2), and secondary analyses of RCT data (SCD-Well trial data from the Medit-Ageing project) examining trait mindfulness, MBI, sleep quality, and SCF in healthy older adults with SCD (Chapter 3; Ch3). Hypotheses in Ch2 were that MBI significantly improve objective cognitive function (H1); that MBI would significantly improve sleep quality (H2); and that sleep quality would mediate putative MBI effects on objective cognitive function (H3), in pooled RCT data collected from older (objectively) cognitively unimpaired adults. In Ch3, it was hypothesized that trait mindfulness would be significantly associated with SCF in older adults with SCD (H1); that MBI would be associated with better SCF over time (post-intervention, follow-up) and would be superior compared to a psychoeducation control group (H2), and finally, that post-intervention sleep quality would mediate the relationship between MBI and SCF at follow-up (H3).

Findings from Ch2 revealed no support for Ch2: H1; there was no significant effect of MBIs on objective cognitive function compared to pooled active controls. There was support for Ch2: H2; MBIs significantly improved sleep quality compared to pooled active controls. However, no mediation studies fitting inclusion criteria were found during systematic search in Ch2, so sleep quality's potential to mediate the MBI relationship to cognitive function remained unclear (Ch2: H3). In Ch3, trait mindfulness was significantly associated with better SCF in individuals with SCD (Ch3: H1) at baseline. Ch3: H2 was not fully supported by findings in Ch3; while MBI was associated with improvement in SCF from baseline to follow-up, its effect was similar to that of psychoeducation (active control). Mediation analysis in Ch3 showed that MBI did not significantly effect sleep quality, and there was no support for a mediation effect of MBI on SCF through sleep quality (Ch3: H3). Considered together, the findings have multiple implications for mindfulness in relation to sleep quality and cognitive ageing that will be explored in this chapter.

## 4.2 MBI and Objective Cognitive Function in Older Adults (Ch2: H1)

The systematic review and meta-analysis of RCTs presented in Ch2 found no significant effect of MBI on cognitive function in healthy older adults across objective cognitive domains of executive function, delayed recall, and free recall. This is an important finding that informed subsequent hypotheses and outcome-focus (e.g., investigating SCF instead of objective cognitive function in Ch3), and warrants broader discussion due to the statistically powerful design (meta-analysis). As discussed in greater length in Ch2 (sections 2.3 and 2.9), the finding contrasts with positive cross-sectional findings (Kurth et al., 2015; Luders et al., 2016; Luders et al., 2011; Prakash et al., 2012) and some RCTs in the cognitively unimpaired (Ford & Nagamatsu, 2024; Malinowski et al., 2017; Moynihan et al., 2013). Other reviews have highlighted mixed cognitive findings across MBI studies of healthy older adults, continuing a trend of ambiguous findings in the field (Berk et al., 2017; Whitfield, Barnhofer, Acabchuk, et al., 2022). On the other hand, there have been positive cognitive outcomes in MBI RCTs in those with cognitive impairment such as MCI (Lin et al., 2023) and early dementia (Quintana-Hernández et al., 2016). There are several possible explanations for these discrepancies.

Firstly, as our pooled sample in Ch2 meta-analysis were cognitively healthy, ceiling effects may have prevented meaningful MBI impact on objective cognitive measures. If longer follow-ups were included in studies, prevention focused outcomes (age-related cognitive decline trajectories) could be assessed, aiming for cognitive maintenance rather than improvements. Alternatively, implementing MBI at an earlier age (e.g., < 50 years) while including education on benefits of sustained long-term mindfulness practice, may also be more effective for improving cognitive function and inducing neuroprotective change (Allen et al., 2012). Promoting trait mindfulness through MBI earlier in life may be of greater benefit for later objective cognitive outcomes (Chételat et al., 2018), while ameliorating poor SCF in shorter timeframes, as was shown in Ch3 (H1, H2).

MBIs are considered an effective means of promoting trait mindfulness (Carmody & Baer, 2008; Kiken et al., 2015), but in studies where MBI is treated as, for example, a cognitive intervention, focus is often solely on cognitive outcomes, and trait mindfulness is not always considered (Tang et al., 2016). MBI studies should assess trait mindfulness at different time points (e.g., baseline, post-intervention, follow-up), a view supported by Tang and colleagues (2016), as change in trait mindfulness is likely key to cognitive improvements and potentially cognitive reserve (Chételat et al., 2018; Malinowski & Shalamanova, 2017). The cognitive advantages observed in long-term meditators in cross-sectional research may reflect cumulative effects on key aspects of trait mindfulness (i.e., attention monitoring and acceptance, see more in Theoretical Implications, 4.5.1) from extended practice that may be harder to produce in 8-week MBI trials (Kurth et al., 2017; Lindsay & Creswell, 2017; Tang et al., 2016). On the other hand, differences in experienced meditators' brains could be due to pre-existing differences in personality or temperament that overlap with or are related to trait mindfulness, which may also have initially caused their interest in practicing mindfulness (Tang et al., 2015). This is why longitudinal designs and longer follow-ups that can ascertain basic mechanism change (e.g., 8-week MBI improving trait mindfulness) are important for future research.

Second, neuropsychological test outcomes in the meta-analysed studies may have lacked the sensitivity to capture subtle or specific mindfulness-related cognitive changes in individuals already performing within normal ranges (Spooner & Pachana, 2006) (see Ch2, 2.9 for more detail on this point). That said, a meta-analysis that attempted to address this found that MBIs outperformed inactive but not active controls across all cognitive domains (Whitfield, Barnhofer, et al., 2022). However, included samples in this meta-analysis were again not limited to those without cognitive impairment, so it is difficult to interpret this finding in the context of cognitively healthy older adults. Possible lack of objective measure sensitivity in healthy older adults was supported by our positive findings for SCF in Ch3.

Our finding in Ch2:H1 could therefore be due to lack of measurement sensitivity to subtle cognitive changes, changes in cognitive domains we could not meta-analyse, or to ceiling effects, as discussed above. Finally, evidence from within individual studies in the Ch2 systematic review support the interpretation that mindfulness benefits healthy older adults' brain function and cognitive reserve. Studies that incorporated neuroimaging measures alongside neuropsychological testing revealed significant improvements in brain structure and function despite absent or modest effects on neuropsychological test scores (Moynihan et al., 2013; Sevinc et al., 2021; Smart et al., 2016). Refer to Ch2 (2.8 and 2.9) for detailed summaries and evaluation of relevant studies. Such brain changes may not translate to improved objective test performance but may confer resilience/reserve against future decline and would be more apparent long-term meditators (see 4.5.2 for expansion on the cognitive reserve hypothesis). Future research should consider that MBI may induce meaningful neural changes that objective cognitive assessments would not capture in cognitively healthy individuals; neuroimaging measures may be more suitable outcomes in this population.

Findings from Ch2: H1 informed Ch3: H1 and H2 where, having ascertained that MBI did not improve objective cognitive function better than active controls the cognitive outcome of interest was instead SCF. SCF scores in those with SCD are associated with future objective cognitive decline (Slot et al., 2019), trait mindfulness and MBI (MacAulay et al., 2022; Smart et al., 2016; Wetherell et al., 2017), and psychological factors and neural profiles that mindfulness is related to (Strikwerda-Brown et al., 2021), which is discussed in detail in section 4.4. Our finding of improved sleep quality in MBI RCTs (Ch2: H2) could also explain why extant mindfulness studies show improved brain health in participants.

### 4.3 Mindfulness-Based Intervention and Sleep Quality (Ch2: H2 & Ch3: H3)

In Ch2, meta-analysis of RCTs demonstrated that MBI had a significant effect on sleep quality compared to control conditions in healthy older adults (Ch2: H2). This finding extended on other reviews and meta-analyses on mindfulness and sleep in older adults (Garland et al., 2016; He et al., 2019; Kim et al., 2022; Li et al., 2025; Rusch et al., 2019) by specifically focusing on standardised MBI in older cognitively healthy populations without diagnosed sleep disorders. The positive effect of MBI on sleep in this population without cognitive impairment or sleep disorder is particularly noteworthy, given that it indicates early intervention before clinical-level issues are present can be impactful, and thus the potential to reduce risk of future dementia is greater (Livingston et al., 2024).

Multiple mechanisms may explain MBI's beneficial effects on sleep quality in those without sleep disorders (Ch2: H2), but no exact mechanisms have been established (Garland et al., 2016). Mindfulness practice, or increased trait mindfulness as a result of practice in MBI, may exert influence on sleep through psychological, cognitive, physiological, and/or neural mechanisms (Shallcross et al., 2019) (see Ch1, 1.5 and Ch3, 3.3 also). These theoretical mechanisms are discussed further in Section 4.5.1 and 4.5.3 below. It remains unclear if MBI effects on sleep work primarily through physiological, psychological, or cognitive mechanisms, or a combination of them, providing impetus for future work to unpack the nature of these relationships.

Despite the significant effects of MBI on sleep quality observed in Ch2 (and the dearth of sleep quality mediation studies, Ch2: H3) which prompted our mediation analysis in Ch3, mediation analysis in Ch3 did not support sleep quality as a mediator between MBI and SCF, nor did MBI directly improve sleep quality. Several factors may explain this unexpected finding (see Ch3, 3.7 also). First, the sample in Ch3 consisted of individuals with SCD who had relatively few sleep issues on average for older adults with SCD, again creating a potential ceiling effect (Youngstedt, 2003). Participants were not recruited based on having sleep difficulties, in contrast to Ch2 meta-analysed studies which included three RCT samples of participants with non-clinical sleep issues. Prevalence of poor sleep quality in older adults, as measured by PSQI (>5 or >7 depending on the study), is 50%, but up to 64% in SCD (Exalto et al., 2022), with scores generally spread across a greater range than in Ch3's sample (Kavousi et al., 2025; Landry et al., 2015). The Ch3 sample had better sleep quality than would be expected in SCD. MBI may therefore be best implemented in older adults with moderate sleep issues or worse for the purpose of improving sleep quality, or in good sleepers for the purpose of preventing age-related sleep decline.

A further explanation for these contrasting findings in Ch2:H2 and Ch3: H3 relates to the temporal sequencing of measurements in the mediation model, which may not have optimally captured the relationship between sleep and SCF. Sleep quality was assessed at post-intervention (8 weeks), while SCF was assessed at follow-up (24 weeks) in Ch3. While such temporal ordering is best-practice in mediation analysis (MacKinnon et al., 2007), the extended interval between these measurements means that post-intervention sleep quality may not have accurately reflected sleep quality changes beyond the intervention period. In Ch2: H2, sleep outcomes were at post-intervention, not follow-up. Additionally, in Ch3 follow-up SCF was most strongly predicted by baseline SCF, suggesting high stability in SCF over time, potentially limiting the ability to detect mediation effects. The direction of causality between sleep quality and SCF may also be more complicated than initially hypothesized (discussed in Ch3, 3.7). It is possible cognitive concerns (i.e., SCF) which characterise SCD may drive or partially drive sleep difficulties rather than vice versa.

A final note on this unexpected finding pertains to the measure of sleep quality used (PSQI) in our studies in Ch2 and Ch3. The studies focused on global PSQI scores, meaning other aspects of sleep associated with SCF and cognitive ageing were not examined. Sleep duration, for example, is linked to cognitive decline, with both short and long sleep duration associated with increased risk (Ma et al., 2020), sleep fragmentation has also been linked to AD risk and accelerated cognitive decline (Lim et al., 2013), and excessive daytime sleepiness has been associated with more severe subjective and objective cognitive decline (Briggs et al., 2025). Furthermore, while the PSQI is widely used and well-validated, it is a subjective self-report instrument that does not capture objective aspects of sleep (Buysse et al., 1989). Objective measures such as actigraphy or polysomnography might provide more precise information about sleep architecture and circadian rhythms (Landry et al., 2015), including slow-wave sleep (SWS) and sleep fragmentation, which have been implicated in cognitive decline and amyloid clearance in the brain during sleep (McCall & Watson, 2021) (see in-depth breakdown in Ch1, 1.4). Landry et al. (2015) advise using subjective and objective sleep measures concurrently to best capture sleep quality in SCD, which was a future research recommendation we made in both Ch2 (2.9) and Ch3 (3.7). Future research utilising objective sleep measures and specific aspects of sleep quality may reveal relationships between MBI/trait mindfulness, sleep, and cognitive outcomes that were not detected using PSQI.

Despite the absence of a mediation effect in Ch3, the Ch2 finding that MBI improves sleep in healthy older adults with non-clinical sleep issues remains an important contribution of this thesis. Sleep quality is associated with numerous health outcomes in older adults, including cardiovascular health, mental health, quality of life, and risk of future cognitive decline and dementia (McCall & Watson, 2021). The improvement in sleep quality in Ch2: H2 is a meaningful finding even in the absence of an effect in better sleepers in Ch3: H3, because improving poor sleep earlier in the cognitively healthy may preserve cognitive function.

## 4.4 Trait Mindfulness, MBI, and Subjective versus Objective Cognitive Function

An interesting pattern emerged across the chapters of this thesis regarding subjective versus objective cognitive outcomes. Ch2 found no significant effect of pooled MBI on objective cognitive function in healthy older adults. In contrast, Ch3 demonstrated that trait mindfulness was uniquely associated with SCF in healthy older adults with SCD, and that both MBI and psychoeducation were associated with improvements in SCF over time. This raises important questions about the nature of mindfulness effects, whether 8-week MBI truly promotes lasting changes in trait mindfulness, and the sensitivity of different assessment approaches.

A number of reasons may explain why trait mindfulness was associated with SCF and MBI improved SCF equivalently to psychoeducation in Ch3, but MBI did not effect objective cognitive function in Ch2. Trait mindfulness, rather than enhancing cognitive performance directly, may influence SCF primarily through psychological pathways that influence how individuals perceive and respond to cognitive changes. In SCD literature, there is not yet a consensus about whether SCF measures truly reflect changes in cognitive ability, or more so reflect increased anxiety and/or depression (Mascherek et al., 2020; Zlatar et al., 2014; Zlatar et al., 2018). Such measurement issues are not unique to SCD, with reviews in dementia (Garg et al., 2022) and chronic illness (Cuevas et al., 2022) also highlighting heterogeneity in criteria used to classify conditions, and in how cognitive difficulties are measured. Higher trait mindfulness has been associated with reduced anxiety and depression in older adults with and without cognitive impairment (Lam et al., 2021), so could have created a buffer against anxiety and depression driving SCF down. Similar to our finding, MacAulay et al. (2023) showed trait mindfulness to be associated with better SCF, as well as reduced depression, anxiety, and perceived stress in older unimpaired adults. Trait mindfulness and/or MBI (if an MBI successfully induces improvement in trait mindfulness) may work through these variables to improve appraisals of cognitive changes, leading to improved SCF (as found in Ch3: H2) but no detectable change in objective cognitive function (as found in Ch2: H1). As there are also recognised associations between depression and anxiety and objective cognitive decline, shown in large systematic review of prospective and longitudinal studies (John et al., 2019), participants in Ch2 who had normal objective cognitive function (all participants) and no SCD (except for in one small group in Smart and colleagues' study) likely had lower or absent depression and anxiety. If mindfulness does indeed impact these psychological factors more so than directly impacting cognitive function in healthy older adults, this could explain the lack of MBI effect in Ch2, and the improvements and significant association with SCF in Ch3.

This interpretation is consistent with the Mindfulness-to-Meaning Theory (Garland et al., 2017), which proposes that one way mindfulness improves psychological outcomes is through improved reappraisal ability. A cross-sectional study by Wesbecher (2018) supports this possible interpretation further; trait mindfulness predicted use of positive re-appraisal strategies, but was not associated with objective cognitive function. It also fits with protective personality traits (e.g., low neuroticism, high conscientiousness) associated with trait mindfulness that likely provide resilience against poor SCF (see related discussion in Ch3, 3.7) (Aschwanden et al., 2022; Hanley & Garland, 2017), but may not impact objective cognition. MAT also offers explanation to Ch2 and Ch3's differing results in subjective and objective cognitive function, which is detailed further in 4.5.1. These possible explanations point to mindfulness aiding in the management of symptoms and/or comorbidities that may influence SCD severity, rather than directly impacting cognitive performance. However, these factors (e.g., worry, anxiety, depression) are also associated with increased risk of cognitive decline and even early neuropathology development in older adults without impairment (Krell-Roesch et al., 2018; Pietrzak et al., 2015; Pink et al., 2022; Verfaillie et al., 2019). Trait mindfulness and MBI is associated with less of this same neuropathology (Heutz, 2017), as well as potential for addressing depression and anxiety (Hofmann et al., 2010; Marchant et al., 2021). Future investigation should strive to clarify if trait mindfulness is associated with improved SCF through brain changes, psychological factors, resilient personality traits, or a mixture. Longer MBIs and/or follow-ups could help further delineate the relationships between these factors and subsequent objective cognitive decline rates.

Another explanation for our contrasting findings could be that SCF is more sensitive than objective cognitive measures to underlying brain degeneration (see Ch3, 3.1), (Stewart, 2012) that may not be apparent on objective outcomes due to cognitive/neural reserve allowing for performance on objective tests in normal ranges (Aschwanden et al., 2022). Briefly, neuroimaging studies show that there are differences in brain health (including amyloid accumulation, grey/white matter thinning, and atrophy in DMN regions) between those with SCD and those without (Mengel et al., 2024; Rivas-Fernández et al., 2023; Sharma et al., 2021; Yingmei et al., 2025). Longitudinal studies examining cognitive trajectories demonstrate that SCD compared to non-SCD is associated with increased risk of progression to dementia when controlling for objective cognitive function (Li et al., 2023; Mitchell et al., 2014). Therefore, trait mindfulness and SCF being uniquely associated in Ch3: H1 might be due to brain differences in those with higher trait mindfulness (e.g., neural reserve, improved DMN function, increased grey matter, less neuropathology), which is indicated in better SCF scores. Such differences may not be detected by objective cognitive measures after 8-week MBI (or perhaps not produced, because MBI was not long enough) as found in Ch2: H1.

Interestingly, both MBI and psychoeducation control produced equivalent improvements in post-intervention and follow-up SCF in Ch3: H2. Baseline objective cognitive function, SCF, trait mindfulness, and demographics were controlled for, suggesting that the beneficial effects were not specific to mindfulness training. The psychoeducation group may have improved in SCF for different reasons. For example, the programme provided information about cognitive ageing, strategies for managing cognitive concerns, and tools for healthy ageing. This could have reduced cognitive concerns through giving participants a sense of control, self-efficacy, and the knowledge that cognitive decline without impairment can be a normal part of ageing. Also important to consider are shared characteristics across the two conditions in Ch3, primarily social engagement (discussed in Ch3, 3.7). Social engagement may also explain the lack of difference between MBI and active controls in objective cognitive outcomes in Ch2: H1. All MBI and control groups in Ch2's pooled RCTs involved closely matched time spent in groups, engaging socially, possibly driving similar changes in cognition. So, the group-based format of all interventions across Ch2 and Ch3 provided social engagement, a factor associated with cognitive health and wellbeing in older adults (Kelly et al., 2017; Monteiro et al., 2024). Disentangling specific effects of MBI from non-specific effects of group participation remains a challenge for future research to address.

## 4.5 Theoretical Implications

The findings of this thesis may have theoretical implications for understanding how mindfulness relates to cognitive function and sleep quality in ageing. These include Monitor and Acceptance Theory (MAT), the cognitive reserve hypothesis, and the DMN as a possible unifying neural mechanism underlying mindfulness effects.

### *4.5.1 Monitor and Acceptance Theory (MAT)*

The discussed Monitor and Acceptance Theory (MAT) provides the most useful framework for interpreting the pattern of results across chapters (Lindsay & Creswell, 2017). The findings from this thesis suggest that the acceptance component of MAT may be particularly relevant for understanding mindfulness effects or lack of effects on objective cognitive function, SCF, and sleep quality in healthy older adults. The association between trait mindfulness and SCF (and also the equivalent improvement in SCF from MBI and psychoeducation) in individuals with SCD (Ch3: H1, H2) likely reflects the role of acceptance in reducing concerns about cognitive function, as the cognitive process of attention monitoring should be intact in this population given the definition of SCD includes normal objective cognitive function. Individuals high in trait mindfulness may more easily be able to accept and not catastrophise about cognitive changes, may experience less distress in response to cognitive difficulties, and may be better able to maintain equanimity in the face of uncertainty about cognitive health (Xu, 2018). Reducing distress appears particularly important for preventing subsequent worry and rumination – acceptance may mitigate strong, emotionally distressing responses to perceived cognitive declines in those with higher trait mindfulness. The direct focus on acceptance skills in the MBI group, and the education and normalisation of cognitive change in the psychoeducation control group in Ch3, may have increased acceptance and reduced distress around perceived cognitive declines in both groups, as alluded to in section 4.4.

MAT can also explain the lack of effect of MBI in healthy older adults on objective cognitive function, and the significant effect on sleep quality, in Ch2 (H1, H2). Objective cognitive outcomes were not based on self-appraisal and therefore would not have been influenced by a psychological mechanism such as acceptance, and possible ceiling effects in attention monitoring (cognitive mechanism) have been discussed (see section 4.2). Sleep quality, however, has been shown to be associated with both aspects of MAT, with perceived stress partially mediating the association (Lau et al., 2018). Well-developed frameworks exist that apply MAT to addressing sleep disturbance (Shallcross et al., 2019). Shallcross and colleagues (2019) map MAT components onto sleep disruption mechanisms, proposing that they reduce secondary arousal, catastrophizing, and counterproductive sleep effort, thereby improving subjective sleep continuity and quality. To briefly detail this framework, it proposes attention monitoring/awareness contributes to addressing sleep disturbance factors of rumination, primary arousal (initial negative appraisal of poor sleep and its anticipated next-day consequences that triggers stress and physiological arousal), secondary arousal (negative judgments towards primary arousal, further stress and physiological arousal), and sleep effort. It then proposes that acceptance addresses distorted perceptions (e.g., overestimating amount of sleep lost), and combined with attention monitoring/awareness, addresses secondary arousal and sleep effort; together, the two mechanisms weaken the rumination-arousal-sleep effort cycle, supporting better sleep.

#### *4.5.2 Cognitive Reserve Hypothesis*

The cognitive reserve hypothesis offers another theoretical lens for understanding mindfulness effects on cognitive ageing. Cognitive reserve refers to the brain's ability to cope with neuropathology through recruitment of alternative neural networks or more efficient use of existing networks, and is influenced by lifelong engagement in cognitive, social, and physical activities (Stern et al., 2020). Trait mindfulness, as a result of mindfulness practice or otherwise, has been proposed to build cognitive reserve (Malinowski & Shalamanova, 2017) through improvements in attentional networks (Bremer et al., 2022; Malinowski, 2013), cultivation of metacognitive awareness (Jankowski & Holas, 2014), openness to experience and curiosity (novelty exposure; fluid intelligence) (Baer et al., 2006; Brown & Ryan, 2003; Gard, Taquet, et al., 2014), and associations with brain changes including increased grey matter density in prefrontal and hippocampal regions (Hölzel, Carmody, et al., 2011; Hölzel, Lazar, et al., 2011).

Evidence from cross-sectional research showing that experienced meditators (min. 4 years meditation experience in Luders and colleagues study) have younger-appearing brains and better-preserved cognitive function compared to non-meditators is consistent with the cognitive reserve hypothesis (Luders et al., 2016). Viewed through the lens of cognitive reserve, mindfulness practice may need to be sustained over months or years rather than weeks to yield cognitive benefits through enhanced cognitive/neural reserve (Kurth et al., 2017). If cognitive reserve is a primary mechanism through which mindfulness influences cognitive function in older adults, significant changes in objective cognitive function post 8-week MBI would not be apparent, as was found in Ch2: H1. A two-year, four-arm RCT (MBI, cognitive stimulation therapy [CST], muscle relaxation, inactive control) in older adults with AD demonstrated that longer periods of MBI could possibly promote cognitive reserve even in cognitively impaired older adults (Quintana-Hernández et al., 2016). MBI, followed closely by CST, was most effective for maintaining all cognitive abilities assessed (language, memory, learning, attention, praxis, tactile/visual perception, calculation, abstract thinking, orientation, expression, understanding) in mild-moderate AD. A possible interpretation is that MBI and CST – also linked to increased reserve (Liu et al., 2021) – increased cognitive reserve over the two-year period, allowing participants to compensate for AD brain pathology, and not decline as expected. Much research on mindfulness and cognitive ageing has focused on objective cognitive outcomes, but investigating trait mindfulness, meditation experience, and MBI and cognitive reserve levels is important to further understand the heterogeneity seen across mindfulness and cognitive ageing research.

### *4.5.3 The Default-Mode Network (DMN) as a Unifying Mindfulness Mechanism*

The DMN has emerged as a potential unifying neural mechanism for understanding relationships between mindfulness, sleep quality, and cognitive function in older adults. The DMN is of particular interest in cognitive ageing because AD pathology predominantly accumulates in its regions more so than in other regions of the brain (Buckner et al., 2005). Therefore, atrophy in the DMN is associated with cognitive decline and increased risk of developing AD. As mentioned throughout the thesis, mindfulness has been associated with improved DMN activity regulation (Brewer, Worhunsky, et al., 2011), stronger DMN functional connectivity (Bremer et al., 2022), increased structural integrity and less pathology in DMN regions (Hölzel, Carmody, et al., 2011). Additionally, trait mindfulness was associated with less AD-related pathology in DMN regions and less objective cognitive decline (over a 5-year period) in older unimpaired adults, even when controlling for personality traits (Strikwerda-Brown et al., 2021). Poor SCF is also associated with worse function and integrity of DMN regions (Buckley et al., 2017; Lee et al., 2023; Sharma et al., 2021), as well as with an increase in AD-related pathology levels (Kuhn et al., 2025; X. Wang et al., 2020; Yingmei et al., 2025). Due to the established possibility that SCF measures are sensitive to these neural changes, findings in Ch3: H1 and H2 may reflect mindfulness protecting against negative DMN changes, resulting in better SCF scores. Another way mindfulness may indirectly impact the DMN (rather than directly regulating activity of the network) is through sleep quality.

As discussed in detail in Ch1 (section 1.4) sleep quality is connected to DMN function and structural health (Cordone et al., 2019). Deactivation of the DMN is thought to be necessary for efficient sleep onset (Marques et al., 2015); individuals with insomnia struggle to suppress DMN activity associated with ruminative worry at bedtime (Killgore et al., 2023). Downregulation in DMN activity also precedes deep SWS (Horovitz et al., 2009), the stage of sleep diminished in older adults, and also where toxic metabolites (AD-related pathologies) are cleared from the brain (McCall & Watson, 2021; Xie et al., 2013). Mindfulness improving DMN function could be key to remaining in SWS and clearing AD-related pathologies. This could offer an explanation for the disparity in findings between Ch2: H2 and Ch3: H3 in sleep outcomes. Ch2's meta-analysis included older adult samples with sleep issues, indicating possible DMN dysregulation, which MBI may have improved. Ch3's sample consisted mostly of individuals with less significant sleep issues than would be expected due to age and SCD, so sleep may have remained unchanged even if MBI impacted the DMN. While Ch3: H3 found no MBI mediation pathway to SCF through sleep, the theoretical rationale for DMN-mediated effects remains compelling and warrants investigation in older adults with sleep disturbance.

Our results, and other converging lines of evidence, suggest that the DMN may represent a common neural mechanism linking mindfulness, sleep quality, and cognitive function in ageing. Where possible, future research should build on this possible unifying mechanism, using neuroimaging measures to capture DMN-related associations between mindfulness and outcomes, especially in individuals with poor SCF and poor sleep.

### 4.6 Methodological Considerations

There are a number of considerations to highlight in relation to the methodology and design across the chapters of this thesis. Duration and "dosage" of meditation/mindfulness practice in MBI (i.e., length of MBI, amount of practice in weekly sessions, and frequency of mindfulness practice required) are important considerations over both chapters. The systematic review in Ch2 included studies that adhered closely to standard MBSR protocol. Ch3 participants similarly followed MBSR closely. MBSR guidelines for duration and dosage, based on the original MBSR program developed for stress reduction and chronic pain management (Kabat-Zinn, 2013), have become standard in MBI research. However, as shown in Ch2: H2 and Ch3: H2, it is unclear if the current format is optimal for producing cognitive health benefits in older adults, particularly those without cognitive impairment (Kurth et al., 2017). Ch2: H2 suggests it does not improve objective cognition, while Ch3: H2 suggests it is as beneficial as psychoeducation for SCF. Longer or more intensive interventions might be necessary to produce objective cognitive benefits. Alternatively, and without compromising study feasibility, future interventions might consider focusing on establishing sustainable mindfulness practice habits with longer follow-up periods after MBI, recognising that benefits may accrue gradually over extended periods. Few studies have examined the optimal duration, intensity, and sustainability of mindfulness practice for cognitive outcomes in older adults, an important gap in the literature to be addressed.

Measurement variation was a methodological issue common to both chapters – albeit in different ways – that may have impacted findings. In Ch2, objective cognitive function was assessed using a variety of neuropsychological tests across the studies included in systematic review and meta-analysis. While this approach allowed for meta-analysis by pooling similarly defined outcomes, some heterogeneity was unavoidable because definitions of cognitive domains and their corresponding measures varied across included studies (detailed in Ch2, 2.7). Similarly in Ch3 (mentioned in section 3.7.1), SCF was assessed using the McNair

Cognitive Difficulties Scale, while other studies on SCD have used different measures, including the Cognitive Change Index, memory complaint questionnaires, and sometimes selected items from mood inventories. This issue complicates future study replication and comparison between our study and others. SCF measurement heterogeneity has been highlighted recently, with emphasise on further standardising SCF assessment in SCD in the future (Munro et al., 2023).

Subjective measurement of both sleep and cognitive function was used across chapters, as well as subjective trait mindfulness in Ch3. While such measures are useful, it is important to highlight that they can be more easily biased and confounded with extraneous variables than objective measures. Sleep quality was assessed using the PSQI (Buysse et al., 1989) across both studies in this thesis. It is a well-validated subjective measure and is widely used in research on sleep and ageing (Fabbri et al., 2021), but there is mixed evidence as to how closely it corresponds to objective sleep quality. Research has shown that subjective and objective sleep measures often do not correlate strongly (Cudney et al., 2022) (See Ch3, 3.7). Similarly, SCF lacks consistent association to objective neuropsychological tests, and it is not fully clear if it represents psychological issues, personality differences, or early neurodegeneration (Molinuevo et al., 2017). Trait mindfulness, as established, overlaps with “big five” personality traits (Hanley & Garland, 2017). The possibility of unconscious biases, confounding, and social desirability should always be highlighted when interpreting subjective outcomes (Van de Mortel, 2008).

### 4.7 Limitations

There are limitations to be considered when interpreting this thesis’ findings and their implications. Limitations specific to each chapter are discussed in Ch2

(2.9.1) and Ch3 (3.7.1). The following discusses limitations common to both chapters. The samples examined in Ch2 and Ch3 were predominantly white, well-educated, and from Western countries, limiting generalisability to more a diverse set of populations. Cultural factors may influence both the acceptability and effectiveness of MBIs, as mindfulness practices originate from Eastern contemplative traditions and may be received differently in various cultural contexts (Anālayo, 2019; Karl et al., 2022). The relationship between mindfulness and subjective cognitive outcomes may also vary across cultural groups due to differences in how cognitive changes are perceived and the meaning attributed to cognitive change in different cultures (Rodríguez et al., 2021). Future research should strive to include more culturally diverse samples to understand whether findings generalise broadly (Munro et al., 2023).

Follow-up time measurements were lacking in studies included in the systematic review in Ch2. Follow-ups are particularly important when investigating MBI effects on healthy older adults' cognitive function, as continued mindfulness practice appears more likely to lead to cognitive benefits (Kurth et al., 2017). Follow-ups could have given insight into whether MBI prevents expected declines in normal cognitive trajectories for older adults, as well as possibly lowering risk of healthy older adults progressing to MCI (Salthouse, 2019). There was one follow-up in Ch3 data, which allowed for temporally ordered mediation, and analysis of variance over time between groups. Yet, further follow-ups would have been useful for assessing longer cognitive trajectories and observing progression (MCI, dementia) rates.

The measure of SCF used to assess severity of SCD in Ch3, and objective cognitive outcomes in Ch2, both had differing limitations but appear to have similar solutions (using neural/brain measures alongside or instead of such measures). We were limited in that the SCD-Well trial data we had access to did not include biomarker assessment, neuroimaging, personality traits, or genetic factors, making it impossible to distinguish SCD severity based on these factors. These confounding variables may have influenced findings. Personality traits, particularly neuroticism and conscientiousness, are associated with both mindfulness (Hanley, 2016) and SCD (Aschwanden et al., 2022), and may confound relationships between these variables if not controlled for. If personality differences had been accounted for in Ch2, it may also have provided insight into personality profiles that MBI is most/least effective in. Other confounders might include lifestyle factors like diet, physical activity, cognitive engagement, and substance use, which all influence cognitive ageing (Livingston et al., 2024) and were not systematically controlled across studies in the thesis.

Finally, some of the methodological considerations discussed previously limit interpretations of findings. The reliance on a subjective measure of sleep quality may have missed important effects on sleep architecture or circadian rhythms that could be detected by objective measurement. The limitations of objective cognitive tests for measuring subtle cognitive or neural changes in unimpaired populations may have limited us in detecting change in cognitive function in Ch2. It was beyond the scope and feasibility of the studies in this thesis to incorporate multiple measurement types (e.g., including or controlling for objective cognition and sleep quality, subjective cognitive and sleep measures, neuroimaging, and psychological and personality measures) and longer follow-ups.

## 4.8 Future Research Directions

Based on the findings and limitations of this thesis, recommendations for future research that would advance understanding of mindfulness effects on cognitive ageing emerged. In future, longer RCTs and/or extended follow-up periods that assess engagement with mindfulness practice post-intervention are needed. This was a recurring recommendation across the thesis, which would help determine whether MBI influences late-life cognitive trajectories and risk of progression to MCI and dementia differently or better than control interventions. This would allow researchers to determine whether MBI prevents or delays cognitive decline rather than producing immediate cognitive performance gains, and to examine relationships between extent of mindfulness practice, changes in trait mindfulness, and long-term cognitive outcomes. In the context of prevention, research focusing on whether mindfulness variables (e.g., frequency of meditation, types of meditation, span and continuity of mindfulness practice, trait mindfulness levels, MBI) promote or contribute to cognitive reserve would be valuable. Future studies should also consider socio-cultural and environmental factors that may influence cognitive reserve, cognitive decline, trait mindfulness, and MBI engagement and efficacy, such as geographical location, cultural attitudes towards mindfulness and cognitive difficulties, socioeconomic status, urbanisation levels, exposure to neurotoxic environments.

In shorter or longer-term studies, use of neuroimaging outcomes with objective and subjective cognitive measures in future work came up repeatedly. This would help advance understanding of mindfulness neural mechanisms, such as examining the proposed mechanisms in MAT (attention monitoring and acceptance) and their neural correlates. Enough studies exist to show that long-term mindfulness practice and high trait mindfulness correlate with better brain health in older adults – to build on this and clarify causation, longitudinal studies with the same neuroimaging outcomes (brain structural and functional measures) are necessary.

If an aim for reducing dementia risk is earlier intervention with greater possibility to impact cognitive trajectories, as Livingston et al. (2024) encourage, MBI may be best investigated when cognition is still intact, with the aim of integrating mindfulness practice into daily living post-intervention (Kurth et al., 2017). However, while patterns of neural and broader brain effects from mindfulness are becoming clearer, there is not yet full consensus of the varying neural effects from different types of mindfulness practices in different older adult profiles (Acevedo et al., 2016; Calderone et al., 2024; Marciniak et al., 2014; Sezer et al., 2022). Research progress in this area will greatly help in informing MBI protocols and frequency of practice guidelines for specific neural and cognitive profiles in older adults. Finally, combining neuroimaging measurement with subjective cognitive measures would allow researchers to further substantiate the idea that poor SCF is a sensitive indicator of incipient neuropathology (Kuhn et al., 2025; Stewart, 2012).

Disentangling effects of social engagement and social support from MBI-specific effects will be important for future research. The group-based format of MBI and controls may have produced benefits through social engagement/support that were independent of intervention content. Comparing group-based MBI to individual MBI delivered in one-on-one sessions would isolate effects of mindfulness from social elements in group MBI, but may come with feasibility and comparison issues. Comparing group-based MBI to social engagement control groups that meet socially for equivalent time but without specific intervention content would similarly isolate intervention-specific effects and may be a more feasible design to undertake. Measuring changes in social isolation and social support, as well as trait mindfulness change, as potential mediators of intervention effects would further help clarify mechanisms of MBI.

### 4.9 Implications & Conclusion

Overall, our findings suggest that mindfulness may influence cognitive health in unimpaired older adults through complex, indirect pathways rather than through direct enhancement of cognitive performance after 8-weeks mindfulness practice. Sleep quality represents one important pathway, given its response to MBI in Ch2 and its established importance for brain health and cognitive function in ageing. However, as sleep quality did not mediate effects of MBI on SCF in the SCD sample who had overall good sleep quality, MBI may be most useful in older populations with moderate-severe sleep problems. We also conclude that DMN function may represent a unifying neural link between mindfulness, sleep, and cognitive ageing, warranting investigation in future research employing neuroimaging methods.

Despite the mixed findings, this thesis has some important clinical and practical implications for supporting cognitive health in older adults. MBI significantly improving sleep quality in healthy older adults with sleep difficulties has direct clinical relevance. Sleep quality is associated with numerous health outcomes including cardiovascular health, mental health, pain, quality of life, and risk of future cognitive decline and dementia (McCall & Watson, 2021). Given the high prevalence of sleep problems in older adults (Gildner et al., 2014) and the limitations and potential adverse effects of pharmacological sleep treatments (De

Crescenzo et al., 2022), MBI represents a valuable non-pharmacological option for improving sleep in this population.

The unique association between trait mindfulness and SCF suggests that promoting trait mindfulness may be particularly beneficial for older adults with SCD, although it is unclear if 8-week MBI is the optimal method for achieving this over psychoeducation. Even in the absence of objective cognitive impairment, poor SCF (high level of concern about cognitive decline) can cause significant distress, impact quality of life, and may lead to increased anxiety and/or depression (Jessen et al., 2020). Because of the co-morbidities observed in SCD (namely anxiety and depression), multicomponent interventions that have demonstrated efficacy in these areas, such as MBI, are recommended over single-component interventions (Mohanty & Kumar, 2022). Additionally, by potentially interrupting the pathway from heightened worry to increased risk of dementia (Verfaillie et al., 2019), mindfulness may serve a neuroprotective role even if direct effects on cognitive function are not immediately evident.

The equivalence of MBI and psychoeducation in producing improvements in SCF in Ch3 suggests that both approaches may be effective clinical options for supporting the wellbeing of older adults with SCD, and further, potentially reducing their risk of progressing to objective cognitive decline. Psychoeducation interventions are potentially easier to implement in clinical settings because they do not require instructors trained in mindfulness teaching, and they may be more culturally acceptable to some populations. Healthcare systems and memory clinics working with older adults with SCD might consider offering both MBI and psychoeducation options, allowing patients to select the approach that best fits their preferences and values, while including the information that MBI may have distinct neuroprotective benefits.

In conclusion, this thesis contributes to the growing body of evidence examining mindfulness as a non-pharmacological approach to supporting healthy cognitive ageing. While direct effects of 8-week MBI on cognitive function in unimpaired older adults were insignificant, benefits for sleep quality in those suffering from sleep issues, and associations between trait mindfulness and SCF suggest that mindfulness may support cognitive health through different pathways. As populations age globally and the prevalence of cognitive decline and dementia increases, identifying effective and accessible interventions to support brain health in later life remains a critical public health priority. MBIs represent one promising approach worthy of continued investigation, particularly in studies that can address the methodological limitations and study design gaps identified in this thesis. The potential for increased trait mindfulness to prevent cognitive decline and/or promote cognitive reserve through improved sleep quality and neuroprotection, rather than enhance cognitive performance in healthy individuals, may be its most important benefit in the context of cognitive ageing. Longitudinal research utilising neuroimaging and examining trait mindfulness change from MBI is essential for fully understanding its role in healthy cognitive ageing. However, the studies in this thesis did contribute to the current literature. Meta-analytic evidence showed MBI improves sleep quality in healthy older adults with subclinical sleep issues, and MBI was shown to be as effective for improving SCF as psychoeducation in older adults with SCD. Trait mindfulness was uniquely associated with better SCF, indicating it may protect against SCD progressing to cognitive impairment.

# References

Acabchuk, R. L., Brisson, J. M., Park, C. L., Babbott-Bryan, N., Parmelee, O. A., & Johnson, B. T. (2021). Therapeutic Effects of Meditation, Yoga, and Mindfulness-Based Interventions for Chronic Symptoms of Mild Traumatic Brain Injury: A Systematic Review and Meta-Analysis. *Appl Psychol Health Well Being*, *13*(1), 34–62. https://doi.org/10.1111/aphw.12244

Acevedo, B. P., Pospos, S., & Lavretsky, H. (2016). The Neural Mechanisms of Meditative Practices: Novel Approaches for Healthy Aging. *Current Behavioral Neuroscience Reports*, *3*(4), 328–339. https://doi.org/10.1007/s40473-016-0098-x

Adams, C. E., McVay, M. A., Stewart, D. W., Vinci, C., Kinsaul, J., Benitez, L., & Copeland, A. L. (2014). Mindfulness Ameliorates the Relationship Between Weight Concerns and Smoking Behavior in Female Smokers: A Cross-sectional Investigation. *Mindfulness*, *5*(2), 179–185. https://doi.org/10.1007/s12671-012-0163-9

Aftanas, L., & Golocheikine, S. (2002). Non-linear dynamic complexity of the human EEG during meditation. *Neuroscience Letters*, *330*(2), 143–146.

Aguirre, E., Woods, R. T., Spector, A., & Orrell, M. (2013). Cognitive stimulation for dementia: a systematic review of the evidence of effectiveness from randomised controlled trials. *Ageing Res Rev*, *12*(1), 253–262. https://doi.org/10.1016/j.arr.2012.07.001

Ahlskog, J. E., Geda, Y. E., Graff-Radford, N. R., & Petersen, R. C. (2011). Physical Exercise as a Preventive or Disease-Modifying Treatment of Dementia and Brain Aging. *Mayo Clinic Proceedings*, *86*(9), 876–884. https://doi.org/10.4065/mcp.2011.0252

Al-Hussaini, A., Dorvlo, A. S., Antony, S. X., Chavan, D., Dave, J., Purecha, V., Al-Rahbi, S., & Al-Adawi, S. (2001). Vipassana meditation:: A naturalistic, preliminary observation in Muscat. *J Sci Res Med Sci*, *3*(2), 87–92.

Albert, M. S. (2011). Changes in cognition. *Neurobiology of Aging*, *32*, S58–S63. https://doi.org/10.1016/j.neurobiolaging.2011.09.010

Allen, M., Dietz, M., Blair, K. S., Van Beek, M., Rees, G., Vestergaard-Poulsen, P., Lutz, A., & Roepstorff, A. (2012). Cognitive-Affective Neural Plasticity following Active-Controlled Mindfulness Intervention. *The Journal of Neuroscience*, *32*(44), 15601–15610. https://doi.org/10.1523/jneurosci.2957-12.2012

Alzheimer's disease facts and figures. (2021). *Alzheimer's & Dementia*, *17*(3), 327–406. https://doi.org/https://doi.org/10.1002/alz.12328

Amariglio, R. E., Buckley, R. F., Mormino, E. C., Marshall, G. A., Johnson, K. A., Rentz, D. M., & Sperling, R. A. (2018). Amyloid-associated increases in longitudinal report of subjective cognitive complaints. *Alzheimer's & Dementia: Translational Research & Clinical Interventions*, *4*(1), 444–449. https://doi.org/10.1016/j.trci.2018.08.005

Amariglio, R. E., Mormino, E. C., Pietras, A. C., Marshall, G. A., Vannini, P., Johnson, K. A., Sperling, R. A., & Rentz, D. M. (2015). Subjective cognitive concerns, amyloid-β, and neurodegeneration in clinically normal elderly. *Neurology*, *85*(1), 56–62. https://doi.org/10.1212/wnl.0000000000001712

Amihai, I., & Kozhevnikov, M. (2015). The Influence of Buddhist Meditation Traditions on the Autonomic System and Attention. *BioMed Research International*, *2015*, 1–13. https://doi.org/10.1155/2015/731579

Anālayo, B. (2019). Adding historical depth to definitions of mindfulness. *Current Opinion in Psychology*, *28*, 11–14.

Ancoli-Israel, S., & Cooke, J. R. (2005). Prevalence and comorbidity of insomnia and effect on functioning in elderly populations. *J Am Geriatr Soc*, *53*(7 Suppl), S264–271. https://doi.org/10.1111/j.1532-5415.2005.53392.x

Andrade, A. G., Sharma, R. A., Miller, M. D., Kam, K., Varga, A. W., & Osorio, R. S. (2018). SLOW WAVE SLEEP DECREASE IS ASSOCIATED WITH INCREASED LEVELS OF CSF Aβ42 IN COGNITIVELY NORMAL OLDER ADULTS [Conference Abstract]. *Alzheimer's and Dementia*, *14*(7), P395. https://doi.org/10.1016/j.jalz.2018.06.293

Andrews-Hanna, J. R., Smallwood, J., & Spreng, R. N. (2014). The default network and self-generated thought: component processes, dynamic control, and clinical relevance. *Ann N Y Acad Sci*, *1316*(1), 29–52. https://doi.org/10.1111/nyas.12360

Arnal, P. J., Sauvet, F., Leger, D., van Beers, P., Bayon, V., Bougard, C., Rabat, A., Millet, G. Y., & Chennaoui, M. (2015). Benefits of Sleep Extension on Sustained Attention and Sleep Pressure Before and During Total Sleep Deprivation and Recovery. *Sleep*, *38*(12), 1935–1943. https://doi.org/10.5665/sleep.5244

Aschwanden, D., Sutin, A. R., Ledermann, T., Luchetti, M., Stephan, Y., Sesker, A. A., Zhu, X., & Terracciano, A. (2022). Subjective Cognitive Decline: Is a Resilient Personality Protective Against Progression to Objective Cognitive Impairment? Findings from Two Community-Based Cohort Studies. *J Alzheimers Dis*, *89*(1), 87–105. https://doi.org/10.3233/jad-220319

Baer, R. A., Carmody, J., & Hunsinger, M. (2012). Weekly change in mindfulness and perceived stress in a mindfulness-based stress reduction program. *Journal of Clinical Psychology*, *68*(7), 755–765.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using Self-Report Assessment Methods to Explore Facets of Mindfulness. *Assessment*, *13*(1), 27–45. https://doi.org/10.1177/1073191105283504

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., Walsh, E., Duggan, D., & Williams, J. M. (2008). Construct validity of the five facet mindfulness questionnaire in meditating and nonmeditating samples. *Assessment*, *15*(3), 329–342. https://doi.org/10.1177/1073191107313003

Ball, H. A., Mcwhirter, L., Ballard, C., Bhome, R., Blackburn, D. J., Edwards, M. J., Fleming, S. M., Fox, N. C., Howard, R., Huntley, J., Isaacs, J. D., Larner, A. J., Nicholson, T. R., Pennington, C. M., Poole, N., Price, G., Price, J. P., Reuber, M., Ritchie, C.,…Carson, A. J. (2020). Functional cognitive disorder: dementia’s blind spot. *Brain*, *143*(10), 2895–2903. https://doi.org/10.1093/brain/awaa224

Balsamo, F., Berretta, E., Meneo, D., Baglioni, C., & Gelfo, F. (2024). The Complex Relationship between Sleep and Cognitive Reserve: A Narrative Review Based on Human Studies. *Brain Sciences*, *14*(7), 654. https://doi.org/10.3390/brainsci14070654

Barger, L. K., Rajaratnam, S. M., Cannon, C. P., Lukas, M. A., Im, K., Goodrich, E. L., Czeisler, C. A., & O'Donoghue, M. L. (2017). Short sleep duration, obstructive sleep apnea, shiftwork, and the risk of adverse cardiovascular events in patients after an acute coronary syndrome. *Journal of the American Heart Association*, *6*(10), e006959.

Barkan, T., Hoerger, M., Gallegos, A. M., Turiano, N. A., Duberstein, P. R., & Moynihan, J. A. (2016). Personality Predicts Utilization of Mindfulness-Based Stress Reduction During and Post-Intervention in a Community Sample of Older Adults. *The Journal of Alternative and Complementary Medicine*, *22*(5), 390–395. https://doi.org/10.1089/acm.2015.0177

Barnes, D. E., & Yaffe, K. (2011). The projected effect of risk factor reduction on Alzheimer's disease prevalence. *The Lancet Neurology*, *10*(9), 819–828. https://doi.org/10.1016/s1474-4422(11)70072-2

Barrows, J. L., & Fleury, J. (2016). Systematic Review of Yoga Interventions to Promote Cardiovascular Health in Older Adults. *Western Journal of Nursing Research*, *38*(6), 753–781. https://doi.org/10.1177/0193945915618610

Baumann, O., & Brooks-Cederqvist, B. (2023). Multimodal assessment of effects of urban environments on psychological wellbeing. *Heliyon*, *9*(6), e16433. https://doi.org/10.1016/j.heliyon.2023.e16433

Baumgart, M., Snyder, H. M., Carrillo, M. C., Fazio, S., Kim, H., & Johns, H. (2015). Summary of the evidence on modifiable risk factors for cognitive decline and dementia: a population-based perspective. *Alzheimer's & Dementia*, *11*(6), 718–726.

Becker, E., Orellana Rios, C. L., Lahmann, C., Rücker, G., Bauer, J., & Boeker, M. (2018). Anxiety as a risk factor of Alzheimer's disease and vascular dementia. *Br J Psychiatry*, *213*(5), 654–660. https://doi.org/10.1192/bjp.2018.173

Berk, L., van Boxtel, M., & van Os, J. (2017). Can mindfulness-based interventions influence cognitive functioning in older adults? A review and considerations for future research. *Aging & mental health*, *21*(11), 1113–1120. https://doi.org/10.1080/13607863.2016.1247423

Black, D. S., O'Reilly, G. A., Olmstead, R., Breen, E. C., & Irwin, M. R. (2015). Mindfulness Meditation and Improvement in Sleep Quality and Daytime Impairment Among Older Adults With Sleep Disturbances. *JAMA Internal Medicine*, *175*(4), 494. https://doi.org/10.1001/jamainternmed.2014.8081

Black, D. S., Sussman, S., Johnson, C. A., & Milam, J. (2012). Trait Mindfulness Helps Shield Decision-Making From Translating Into Health-Risk Behavior. *Journal of Adolescent Health*, *51*(6), 588–592. https://doi.org/https://doi.org/10.1016/j.jadohealth.2012.03.011

Blondell, S. J., Hammersley-Mather, R., & Veerman, J. L. (2014). Does physical activity prevent cognitive decline and dementia?: A systematic review and meta-analysis of longitudinal studies. *BMC Public Health*, *14*(1), 510. https://doi.org/10.1186/1471-2458-14-510

Bowen, S., Chawla, N., Grow, J., & Marlatt, G. A. (2021). *Mindfulness-based relapse prevention for addictive behaviors: A clinician's guide*. Guilford Publications.

Bowen, S., Vieten, C., Witkiewitz, K., & Carroll, H. (2015). A mindfulness-based approach to addiction. In *Handbook of mindfulness: Theory, research, and practice.* (pp. 387–404). The Guilford Press.

Branger, P., Arenaza-Urquijo, E. M., Tomadesso, C., Mézenge, F., André, C., de Flores, R., Mutlu, J., de La Sayette, V., Eustache, F., Chételat, G., & Rauchs, G. (2016). Relationships between sleep quality and brain volume, metabolism, and amyloid deposition in late adulthood. *Neurobiology of*

*Aging*, *41*, 107–114. https://doi.org/https://doi.org/10.1016/j.neurobiolaging.2016.02.009

Bransby, L., Buckley, R. F., Rosenich, E., Franks, K. H., Yassi, N., Maruff, P., Pase, M. P., & Lim, Y. Y. (2022). The relationship between cognitive engagement and better memory in midlife. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring*, *14*(1). https://doi.org/10.1002/dad2.12278

Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proc Natl Acad Sci U S A*, *104*(27), 11483–11488. https://doi.org/10.1073/pnas.0606552104

Bremer, B., Wu, Q., Mora Álvarez, M. G., Hölzel, B. K., Wilhelm, M., Hell, E., Tavacioglu, E. E., Torske, A., & Koch, K. (2022). Mindfulness meditation increases default mode, salience, and central executive network connectivity. *Sci Rep*, *12*(1), 13219. https://doi.org/10.1038/s41598-022-17325-6

Brewer, J. A., Mallik, S., Babuscio, T. A., Nich, C., Johnson, H. E., Deleone, C. M., Minnix-Cotton, C. A., Byrne, S. A., Kober, H., & Weinstein, A. J. (2011). Mindfulness training for smoking cessation: results from a randomized controlled trial. *Drug and alcohol dependence*, *119*(1-2), 72–80.

Brewer, J. A., Sinha, R., Chen, J. A., Michalsen, R. N., Babuscio, T. A., Nich, C., Grier, A., Bergquist, K. L., Reis, D. L., Potenza, M. N., Carroll, K. M., & Rounsaville, B. J. (2009). Mindfulness training and stress reactivity in substance abuse: results from a randomized, controlled stage I pilot study. *Subst Abus*, *30*(4), 306–317. https://doi.org/10.1080/08897070903250241

Brewer, J. A., Worhunsky, P. D., Gray, J. R., Tang, Y.-Y., Weber, J., & Kober, H. (2011). Meditation experience is associated with differences in default mode network activity and connectivity. *Proceedings of the National Academy of Sciences*, *108*(50), 20254–20259. https://doi.org/10.1073/pnas.1112029108

Brickman, A. M., Paul, R. H., Cohen, R. A., Williams, L. M., MacGregor, K. L., Jefferson, A. L., Tate, D. F., Gunstad, J., & Gordon, E. (2005). Category and letter verbal fluency across the adult lifespan: relationship to EEG theta power. *Arch Clin Neuropsychol*, *20*(5), 561–573. https://doi.org/10.1016/j.acn.2004.12.006

Briggs, A. Q., Boza-Calvo, C., Bernard, M. A., Rusinek, H., Betensky, R. A., & Masurkar, A. V. (2025). The association between measures of sleepiness and subjective cognitive decline symptoms in a diverse population of cognitively normal older adults. *Journal of Alzheimer's Disease*, *105*(3), 740–744. https://doi.org/10.1177/13872877251331237

Brisbon, N. M., & Lachman, M. E. (2017). Dispositional Mindfulness and Memory Problems: the Role of Perceived Stress and Sleep Quality. *Mindfulness*, *8*(2), 379–386. https://doi.org/10.1007/s12671-016-0607-8

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of personality and social psychology*, *84*(4), 822.

Bubb, R. (2014). *Mindfulness-based stress reduction as a cognitive intervention in older adults: A feasibility study* ProQuest Information & Learning]. APA PsycInfo. https://login.jproxy.nuim.ie/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2015-99180-079&site=ehost-live

Buckley, R. F., Hanseeuw, B., Schultz, A. P., Vannini, P., Aghjayan, S. L., Properzi, M. J., Jackson, J. D., Mormino, E. C., Rentz, D. M., Sperling, R. A., Johnson,

K. A., & Amariglio, R. E. (2017). Region-Specific Association of Subjective Cognitive Decline With Tauopathy Independent of Global β-Amyloid Burden. *JAMA Neurol*, *74*(12), 1455–1463. https://doi.org/10.1001/jamaneurol.2017.2216

Buckner, R. L., Snyder, A. Z., Shannon, B. J., LaRossa, G., Sachs, R., Fotenos, A. F., Sheline, Y. I., Klunk, W. E., Mathis, C. A., Morris, J. C., & Mintun, M. A. (2005). Molecular, Structural, and Functional Characterization of Alzheimer's Disease: Evidence for a Relationship between Default Activity, Amyloid, and Memory. *The Journal of Neuroscience*, *25*(34), 7709–7717. https://doi.org/10.1523/jneurosci.2177-05.2005

Buysse, D. J., Monk, T. H., Carrier, J., & Begley, A. (2005). Circadian patterns of sleep, sleepiness, and performance in older and younger adults. *Sleep*, *28*(11), 1365–1376.

Buysse, D. J., Reynolds, C. F., 3rd, Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*, *28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Cabeza, R., Albert, M., Belleville, S., Craik, F. I., Duarte, A., Grady, C. L., Lindenberger, U., Nyberg, L., Park, D. C., & Reuter-Lorenz, P. A. (2018). Maintenance, reserve and compensation: the cognitive neuroscience of healthy ageing. *Nature Reviews Neuroscience*, *19*(11), 701–710.

Cahn, B. R., Goodman, M. S., Peterson, C. T., Maturi, R., & Mills, P. J. (2017). Yoga, Meditation and Mind-Body Health: Increased BDNF, Cortisol Awakening Response, and Altered Inflammatory Marker Expression after a

3-Month Yoga and Meditation Retreat. *Frontiers in Human Neuroscience*, *11*. https://doi.org/10.3389/fnhum.2017.00315

Cahn, B. R., & Polich, J. (2006). Meditation states and traits: EEG, ERP, and neuroimaging studies. *Psychological bulletin*, *132*(2), 180.

Calderone, A., Latella, D., Impellizzeri, F., de Pasquale, P., Famà, F., Quartarone, A., & Calabrò, R. S. (2024). Neurobiological Changes Induced by Mindfulness and Meditation: A Systematic Review. *Biomedicines*, *12*(11). https://doi.org/10.3390/biomedicines12112613

Cappa, S. F., Ribaldi, F., Chicherio, C., & Frisoni, G. B. (2024). Subjective cognitive decline: Memory complaints, cognitive awareness, and metacognition. *Alzheimer's & Dementia*, *20*(9), 6622–6631. https://doi.org/10.1002/alz.13905

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *J Behav Med*, *31*(1), 23–33. https://doi.org/10.1007/s10865-007-9130-7

Carskadon, M. A., & Rechtschaffen, A. (2011). Monitoring and staging human sleep. *Principles and practice of sleep medicine*, *5*, 16–26.

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of educational psychology*, *54*(1), 1.

Chen, T.-L., Chang, S.-C., Huang, C.-Y., & Wang, H.-H. (2021). Effectiveness of mindfulness-based interventions on quality of life and menopausal symptoms in menopausal women: A meta-analysis. *Journal of Psychosomatic Research*, *147*, 110515. https://doi.org/https://doi.org/10.1016/j.jpsychores.2021.110515

Chen, T. L., Chang, S. C., Hsieh, H. F., Huang, C. Y., Chuang, J. H., & Wang, H. H. (2020). Effects of mindfulness-based stress reduction on sleep quality and mental health for insomnia patients: A meta-analysis. *Journal of Psychosomatic Research*, *135*, Article 110144. https://doi.org/10.1016/j.jpsychores.2020.110144

Chételat, G., Lutz, A., Arenaza-Urquijo, E., Collette, F., Klimecki, O., & Marchant, N. (2018). Why could meditation practice help promote mental health and well-being in aging? *Alzheimers Res Ther*, *10*(1), 57. https://doi.org/10.1186/s13195-018-0388-5

Chételat, G., Mézenge, F., Tomadesso, C., Landeau, B., Arenaza-Urquijo, E., Rauchs, G., André, C., De Flores, R., Egret, S., Gonneaud, J., Poisnel, G., Chocat, A., Quillard, A., Desgranges, B., Bloch, J.-G., Ricard, M., & Lutz, A. (2017). Reduced age-associated brain changes in expert meditators: a multimodal neuroimaging pilot study. *Scientific Reports*, *7*(1). https://doi.org/10.1038/s41598-017-07764-x

Chiesa, A., & Serretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: a review and meta-analysis. *The Journal of Alternative and Complementary Medicine*, *15*(5), 593–600.

Child, N. D., & Benarroch, E. E. (2013). Anterior nucleus of the thalamus: functional organization and clinical implications. *Neurology*, *81*(21), 1869–1876. https://doi.org/10.1212/01.wnl.0000436078.95856.56

Chin, B., Lindsay, E. K., Greco, C. M., Brown, K. W., Smyth, J. M., Wright, A. G. C., & Creswell, J. D. (2019). Psychological mechanisms driving stress resilience in mindfulness training: A randomized controlled trial. *Health Psychol*, *38*(8), 759–768. https://doi.org/10.1037/hea0000763

Chua, E. C., Yeo, S. C., Lee, I. T., Tan, L. C., Lau, P., Cai, S., Zhang, X., Puvanendran, K., & Gooley, J. J. (2014). Sustained attention performance during sleep deprivation associates with instability in behavior and physiologic measures at baseline. *Sleep*, *37*(1), 27–39. https://doi.org/10.5665/sleep.3302

Cipriani, G., Lucetti, C., Danti, S., & Nuti, A. (2015). Sleep disturbances and dementia. *Psychogeriatrics*, *15*(1), 65–74.

Conversano, C., Orrù, G., Pozza, A., Miccoli, M., Ciacchini, R., Marchi, L., & Gemignani, A. (2021). Is Mindfulness-Based Stress Reduction Effective for People with Hypertension? A Systematic Review and Meta-Analysis of 30 Years of Evidence. *International Journal of Environmental Research and Public Health*, *18*(6), 2882. https://doi.org/10.3390/ijerph18062882

Cordone, S., Annarumma, L., Rossini, P. M., & De Gennaro, L. (2019). Sleep and β-Amyloid Deposition in Alzheimer Disease: Insights on Mechanisms and Possible Innovative Treatments. *Front Pharmacol*, *10*, 695. https://doi.org/10.3389/fphar.2019.00695

Craigmyle, N. A. (2013). The beneficial effects of meditation: contribution of the anterior cingulate and locus coeruleus. *Front Psychol*, *4*, 731. https://doi.org/10.3389/fpsyg.2013.00731

Crane, R. S., Brewer, J., Feldman, C., Kabat-Zinn, J., Santorelli, S., Williams, J. M. G., & Kuyken, W. (2017). What defines mindfulness-based programs? The warp and the weft. *Psychological Medicine*, *47*(6), 990–999. https://doi.org/10.1017/s0033291716003317

Creswell, J. D. (2017). Mindfulness interventions. *Annual review of psychology*, *68*(1), 491–516.

Creswell, J. D., Irwin, M. R., Burklund, L. J., Lieberman, M. D., Arevalo, J. M., Ma, J., Breen, E. C., & Cole, S. W. (2012). Mindfulness-Based Stress Reduction training reduces loneliness and pro-inflammatory gene expression in older adults: a small randomized controlled trial. *Brain Behav Immun*, *26*(7), 1095–1101. https://doi.org/10.1016/j.bbi.2012.07.006

Creswell, J. D., Taren, A. A., Lindsay, E. K., Greco, C. M., Gianaros, P. J., Fairgrieve, A., Marsland, A. L., Brown, K. W., Way, B. M., Rosen, R. K., & Ferris, J. L. (2016). Alterations in Resting-State Functional Connectivity Link Mindfulness Meditation With Reduced Interleukin-6: A Randomized Controlled Trial. *Biol Psychiatry*, *80*(1), 53–61. https://doi.org/10.1016/j.biopsych.2016.01.008

Cudney, L. E., Frey, B. N., McCabe, R. E., & Green, S. M. (2022). Investigating the relationship between objective measures of sleep and self-report sleep quality in healthy adults: a review. *Journal of Clinical Sleep Medicine*, *18*(3), 927–936. https://doi.org/10.5664/jcsm.9708

Cuevas, H., Danesh, V., & Henneghan, A. (2022). Self-Reported Cognitive Function in Persons with Nonneurological Chronic Diseases: A Systematic Review. *J Aging Res*, *2022*, 5803337. https://doi.org/10.1155/2022/5803337

Daffner, K. R. (2010). Promoting Successful Cognitive Aging: A Comprehensive Review. *Journal of Alzheimer's Disease*, *19*(4), 1101–1122. https://doi.org/10.3233/jad-2010-1306

Daffner, K. R., Ryan, K. K., Williams, D. M., Budson, A. E., Rentz, D. M., Wolk, D. A., & Holcomb, P. J. (2006). Increased Responsiveness to Novelty is Associated with Successful Cognitive Aging. *Journal of Cognitive Neuroscience*, *18*, 1759–1773. https://doi.org/10.1162/jocn.2006.18.10.1759

Damoiseaux, J. S., Beckmann, C., Arigita, E. S., Barkhof, F., Scheltens, P., Stam, C., Smith, S., & Rombouts, S. (2008). Reduced resting-state brain activity in the “default network” in normal aging. *Cerebral Cortex*, *18*(8), 1856–1864.

Darehzereshki, S., Dehghani, F., & Enjezab, B. (2022). Mindfulness-based stress reduction group training improves of sleep quality in postmenopausal women. *BMC Psychiatry*, *22*(1), 254. https://doi.org/10.1186/s12888-022-03869-4

Darowski, E. S., Helder, E., Zacks, R. T., Hasher, L., & Hambrick, D. Z. (2008). Age-related differences in cognition: the role of distraction control. *Neuropsychology*, *22*(5), 638–644. https://doi.org/10.1037/0894-4105.22.5.638

Davidson, R. J., Kabat-Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F., Urbanowski, F., Harrington, A., Bonus, K., & Sheridan, J. F. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosom Med*, *65*(4), 564–570. https://doi.org/10.1097/01.psy.0000077505.67574.e3

De Crescenzo, F., D'Alò, G. L., Ostinelli, E. G., Ciabattini, M., Di Franco, V., Watanabe, N., Kurtulmus, A., Tomlinson, A., Mitrova, Z., Foti, F., Del Giovane, C., Quested, D. J., Cowen, P. J., Barbui, C., Amato, L., Efthimiou, O., & Cipriani, A. (2022). Comparative effects of pharmacological interventions for the acute and long-term management of insomnia disorder in adults: a systematic review and network meta-analysis. *The Lancet*, *400*(10347), 170–184. https://doi.org/10.1016/s0140-6736(22)00878-9

Deary, I. J., Corley, J., Gow, A. J., Harris, S. E., Houlihan, L. M., Marioni, R. E., Penke, L., Rafnsson, S. B., & Starr, J. M. (2009). Age-associated cognitive decline. *British medical bulletin*, *92*(1), 135–152.

Department of Economic and Social Affairs PD. (2007). *World Population Ageing*. New York: United Nations Publications

Dickerson, B. C., & Eichenbaum, H. (2010). The Episodic Memory System: Neurocircuitry and Disorders. *Neuropsychopharmacology*, *35*(1), 86–104. https://doi.org/10.1038/npp.2009.126

Espinoza Jeraldo, R. I., Zabihi, S., Miranda-Castillo, C., Marshall, C. R., & Cooper, C. (2024). *Lifestyle interventions for dementia prevention in Low- and Middle-Income Countries: A systematic review*. Cold Spring Harbor Laboratory.

Exalto, L. G., Hendriksen, H. M. A., Barkhof, F., Van Den Bosch, K. A., Ebenau, J. L., Van Leeuwenstijn-Koopman, M., Prins, N. D., Teunissen, C. E., Visser, L. N. C., Scheltens, P., & Van Der Flier, W. M. (2022). Subjective cognitive decline and self-reported sleep problems: The SCIENCe project. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring*, *14*(1). https://doi.org/10.1002/dad2.12287

Fabbri, M., Beracci, A., Martoni, M., Meneo, D., Tonetti, L., & Natale, V. (2021). Measuring Subjective Sleep Quality: A Review. *Int J Environ Res Public Health*, *18*(3). https://doi.org/10.3390/ijerph18031082

Fam, J., Sun, Y., Qi, P., Lau, R. C., Feng, L., Kua, E. H., & Mahendran, R. (2020). Mindfulness practice alters brain connectivity in community-living elders with mild cognitive impairment. *Psychiatry and Clinical Neurosciences*, *74*(4), 257–262. https://doi.org/10.1111/pcn.12972

Ferreira, L. K., Regina, A. C. B., Kovacevic, N., Martin, M. d. G. M., Santos, P. P., Carneiro, C. d. G., Kerr, D. S., Amaro, E., Jr, McIntosh, A. R., & Busatto, G. F. (2016). Aging Effects on Whole-Brain Functional Connectivity in Adults Free of Cognitive and Psychiatric Disorders. *Cerebral Cortex*, *26*(9), 3851–3865. https://doi.org/10.1093/cercor/bhv190

Fiocco, A. J., & Mallya, S. (2015). The importance of cultivating mindfulness for cognitive and emotional well-being in late life [Article]. *Journal of evidence-based complementary & alternative medicine*, *20*(1), 35–40. https://doi.org/10.1177/2156587214553940

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*, *12*(3), 189–198. https://doi.org/10.1016/0022-3956(75)90026-6

Ford, S. D., & Nagamatsu, L. S. (2024). Four weeks of meditation training improves sustained attention in community-dwelling older adults: a proof-of-concept randomized controlled trial. *Frontiers in Aging*, *5*. https://doi.org/10.3389/fragi.2024.1322705

Fountain-Zaragoza, S., Londerée, A., Whitmoyer, P., & Prakash, R. S. (2016). Dispositional mindfulness and the wandering mind: Implications for attentional control in older adults. *Conscious Cogn*, *44*, 193–204. https://doi.org/10.1016/j.concog.2016.08.003

Fountain-Zaragoza, S., & Prakash, R. S. (2017). Mindfulness training for healthy aging: Impact on attention, well-being, and inflammation [Review]. *Frontiers in Aging Neuroscience*, *9*(FEB). https://doi.org/10.3389/fnagi.2017.00011

Fox, K. C. R., Dixon, M. L., Nijeboer, S., Girn, M., Floman, J. L., Lifshitz, M., Ellamil, M., Sedlmeier, P., & Christoff, K. (2016). Functional neuroanatomy of meditation: A review and meta-analysis of 78 functional neuroimaging investigations. *Neuroscience & Biobehavioral Reviews*, *65*, 208–228. https://doi.org/10.1016/j.neubiorev.2016.03.021

Fox, K. C. R., Nijeboer, S., Dixon, M. L., Floman, J. L., Ellamil, M., Rumak, S. P., Sedlmeier, P., & Christoff, K. (2014). Is meditation associated with altered brain structure? A systematic review and meta-analysis of morphometric neuroimaging in meditation practitioners. *Neuroscience & Biobehavioral Reviews*, *43*, 48–73. https://doi.org/10.1016/j.neubiorev.2014.03.016

Franco, C., Amutio, A., Mañas, I., Gázquez, J. J., & Pérez-Fuentes, M. d. C. (2017). Reducing anxiety, geriatric depression and worry in a sample of older adults through a mindfulness training program. *Terapia Psicológica*, *35*(1), 71–79. (IN FILE)

Franke, K., Ziegler, G., Klöppel, S., & Gaser, C. (2010). Estimating the age of healthy subjects from T1-weighted MRI scans using kernel methods: exploring the influence of various parameters. *NeuroImage*, *50*(3), 883–892. https://doi.org/10.1016/j.neuroimage.2010.01.005

Froeliger, B., Mathew, A. R., McConnell, P. A., Eichberg, C., Saladin, M. E., Carpenter, M. J., & Garland, E. L. (2017). Restructuring Reward Mechanisms in Nicotine Addiction: A Pilot fMRI Study of Mindfulness-Oriented Recovery Enhancement for Cigarette Smokers. *Evid Based Complement Alternat Med*, *2017*, 7018014. https://doi.org/10.1155/2017/7018014

Gabelica, M., Bojčić, R., & Puljak, L. (2022). Many researchers were not compliant with their published data sharing statement: a mixed-methods study. *J Clin Epidemiol*, *150*, 33–41. https://doi.org/10.1016/j.jclinepi.2022.05.019

Gagnadoux, F., Le Vaillant, M., Goupil, F., Pigeanne, T., Chollet, S., Masson, P., Bizieux-Thaminy, A., Humeau, M.-P., & Meslier, N. (2014). Depressive symptoms before and after long-term CPAP therapy in patients with sleep apnea. *Chest*, *145*(5), 1025–1031.

Gallegos, A., Moynihan, J., & Pigeon, W. R. (2013). Impact of a mindfulness-based stress reduction program on sleep quality among older adults [Conference Abstract]. *Sleep*, *36*, A228.

Gallegos, A. M., Moynihan, J., & Pigeon, W. R. (2018). A Secondary Analysis of Sleep Quality Changes in Older Adults From a Randomized Trial of an MBSR Program. *Journal of Applied Gerontology*, *37*(11), 1327–1343. https://doi.org/10.1177/0733464816663553

Ganesan, S., Beyer, E., Moffat, B., Van Dam, N. T., Lorenzetti, V., & Zalesky, A. (2022). Focused attention meditation in healthy adults: A systematic review and meta-analysis of cross-sectional functional MRI studies. *Neuroscience & Biobehavioral Reviews*, *141*, 104846. https://doi.org/https://doi.org/10.1016/j.neubiorev.2022.104846

Ganesan, S., Moffat, B., Dam, N. T. V., Lorenzetti, V., & Zalesky, A. (2023). Meditation attenuates Default-mode activity: a pilot study using ultra-high strength MRI. *bioRxiv*, 2023.2001.2002.522524. https://doi.org/10.1101/2023.01.02.522524

Gard, T., Hölzel, B. K., & Lazar, S. W. (2014). The potential effects of meditation on age-related cognitive decline: a systematic review. *Annals of the New York Academy of Sciences*, *1307*(1), 89–103. https://doi.org/10.1111/nyas.12348

Gard, T., Taquet, M., Dixit, R., Hölzel, B. K., de Montjoye, Y.-A., Brach, N., Salat, D. H., Dickerson, B. C., Gray, J. R., & Lazar, S. W. (2014). Fluid intelligence and brain functional organization in aging yoga and meditation practitioners. *Frontiers in Aging Neuroscience*, *6*.

Gard, T., Taquet, M., Dixit, R., Hölzel, B. K., Dickerson, B. C., & Lazar, S. W. (2015). Greater widespread functional connectivity of the caudate in older adults who practice kripalu yoga and vipassana meditation than in controls [Original Research]. *Frontiers in Human Neuroscience*, *9*. https://doi.org/10.3389/fnhum.2015.00137

Gardner, R., Jr., Oliver-Muñoz, S., Fisher, L., & Empting, L. (1981). Mattis Dementia Rating Scale: internal reliability study using a diffusely impaired population. *J Clin Neuropsychol*, *3*(3), 271–275. https://doi.org/10.1080/01688638108403130

Garg, D., Gupta, A., Agarwal, A., Mishra, B., Srivastava, M. V. P., Basheer, A., & Vishnu, V. Y. (2022). Latest Trends in Outcome Measures in Dementia and Mild Cognitive Impairment Trials. *Brain Sci*, *12*(7). https://doi.org/10.3390/brainsci12070922

Garland, E. L. (2024). *Mindfulness-Oriented Recovery Enhancement*. Guilford Publications.

Garland, E. L., Farb, N. A., R. Goldin, P., & Fredrickson, B. L. (2015). Mindfulness Broadens Awareness and Builds Eudaimonic Meaning: A Process Model of

Mindful Positive Emotion Regulation. *Psychological Inquiry*, *26*(4), 293–314. https://doi.org/10.1080/1047840X.2015.1064294

Garland, E. L., Froeliger, B., & Howard, M. O. (2014). Mindfulness Training Targets Neurocognitive Mechanisms of Addiction at the Attention-Appraisal-Emotion Interface. *Frontiers in Psychiatry*, *4*. https://doi.org/10.3389/fpsyt.2013.00173

Garland, E. L., Hanley, A. W., Goldin, P. R., & Gross, J. J. (2017). Testing the mindfulness-to-meaning theory: Evidence for mindful positive emotion regulation from a reanalysis of longitudinal data. *PLoS One*, *12*(12), e0187727. https://doi.org/10.1371/journal.pone.0187727

Garland, E. L., & Howard, M. O. (2018). Mindfulness-based treatment of addiction: current state of the field and envisioning the next wave of research. *Addiction Science & Clinical Practice*, *13*(1). https://doi.org/10.1186/s13722-018-0115-3

Garland, S. N., Zhou, E. S., Gonzalez, B. D., & Rodriguez, N. (2016). The Quest for Mindful Sleep: a Critical Synthesis of the Impact of Mindfulness-Based Interventions for Insomnia. *Current sleep medicine reports*, *2*(3), 142–151. https://doi.org/10.1007/s40675-016-0050-3

Gass, C. S., Patten, B., Penate, A., & Rhodes, A. (2021). The Cognitive Difficulties Scale (CDS): Psychometric Characteristics in a Clinical Referral Sample. *Journal of the International Neuropsychological Society*, *27*(4), 351–364. https://doi.org/10.1017/S1355617720001058

Gava, G., Orsili, I., Alvisi, S., Mancini, I., Seracchioli, R., & Meriggiola, M. C. (2019). Cognition, Mood and Sleep in Menopausal Transition. *Medicina (Kaunas)*, *55*(10). https://doi.org/10.3390/medicina55100668

Gildner, T. E., Liebert, M. A., Kowal, P., Chatterji, S., & Snodgrass, J. J. (2014). Associations between Sleep Duration, Sleep Quality, and Cognitive Test Performance among Older Adults from Six Middle Income Countries: Results from the Study on Global Ageing and Adult Health (SAGE). *Journal of Clinical Sleep Medicine*, *10*(06), 613–621. https://doi.org/10.5664/jcsm.3782

Giluk, T. L. (2009). Mindfulness, Big Five personality, and affect: A meta-analysis. *Personality and Individual Differences*, *47*(8), 805–811.

Glisky, E. L. (2007). Changes in cognitive function in human aging. In *Brain aging: Models, methods, and mechanisms.* (pp. 3–20). CRC Press/Routledge/Taylor & Francis Group. https://doi.org/10.1201/9781420005523.sec1

Goldberg, E. (1994). Cognitive novelty. *Neurosciences*, *6*, 371–378.

Goldberg, S. B. (2022). A common factors perspective on mindfulness-based interventions. *Nature Reviews Psychology*, *1*(10), 605–619. https://doi.org/10.1038/s44159-022-00090-8

Gong, H., Ni, C.-X., Liu, Y.-Z., Zhang, Y., Su, W.-J., Lian, Y.-J., Peng, W., & Jiang, C.-L. (2016). Mindfulness meditation for insomnia: A meta-analysis of randomized controlled trials. *Journal of Psychosomatic Research*, *89*, 1–6.

Gonzales, M. M., Garbarino, V. R., Pollet, E., Palavicini, J. P., Kellogg, D. L., Jr., Kraig, E., & Orr, M. E. (2022). Biological aging processes underlying cognitive decline and neurodegenerative disease. *J Clin Invest*, *132*(10). https://doi.org/10.1172/jci158453

Gothe, N. P., Kramer, A. F., & Mcauley, E. (2014). The Effects of an 8-Week Hatha Yoga Intervention on Executive Function in Older Adults. *The Journals of*

*Gerontology: Series A*, *69*(9), 1109–1116. https://doi.org/10.1093/gerona/glu095

Gothe, N. P., Kramer, A. F., & McAuley, E. (2017). Hatha Yoga Practice Improves Attention and Processing Speed in Older Adults: Results from an 8-Week Randomized Control Trial. *J Altern Complement Med*, *23*(1), 35–40. https://doi.org/10.1089/acm.2016.0185

Gottlieb, D. J., Whitney, C. W., Bonekat, W. H., Iber, C., James, G. D., Lebowitz, M., Nieto, F. J., & Rosenberg, C. E. (1999). Relation of sleepiness to respiratory disturbance index: the Sleep Heart Health Study. *American Journal of Respiratory and Critical Care Medicine*, *159*(2), 502–507.

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits: A meta-analysis. *Journal of Psychosomatic Research*, *57*(1), 35–43.

Gu, Y., Janoschka, S., & Ge, S. (2013). Neurogenesis and Hippocampal Plasticity in Adult Brain. In C. Belzung & P. Wigmore (Eds.), *Neurogenesis and Neural Plasticity* (pp. 31–48). Springer Berlin Heidelberg. https://doi.org/10.1007/7854_2012_217

Guidi, J., Brakemeier, E.-L., Bockting, Claudi L. H., Cosci, F., Cuijpers, P., Jarrett, Robin B., Linden, M., Marks, I., Peretti, Charles S., Rafanelli, C., Rief, W., Schneider, S., Schnyder, U., Sensky, T., Tomba, E., Vazquez, C., Vieta, E., Zipfel, S., Wright, Jesse H., & Fava, Giovanni A. (2018). Methodological Recommendations for Trials of Psychological Interventions. *Psychotherapy and Psychosomatics*, *87*(5), 276–284. https://doi.org/10.1159/000490574

Gulpers, B., Ramakers, I., Hamel, R., Köhler, S., Oude Voshaar, R., & Verhey, F. (2016). Anxiety as a Predictor for Cognitive Decline and Dementia: A

Systematic Review and Meta-Analysis. *Am J Geriatr Psychiatry*, *24*(10), 823–842. https://doi.org/10.1016/j.jagp.2016.05.015

Hafkemeijer, A., van der Grond, J., & Rombouts, S. A. (2012). Imaging the default mode network in aging and dementia. *Biochimica et Biophysica Acta (BBA)-Molecular Basis of Disease*, *1822*(3), 431–441.

Han, A. (2022). Mindfulness-Based Interventions for Older Adults with Dementia or Mild Cognitive Impairment: A Meta-Analysis. *Clinical Gerontologist*, *45*(4), 763–776. https://doi.org/10.1080/07317115.2021.1995561

Hanley, A. W. (2016). The mindful personality: Associations between dispositional mindfulness and the Five Factor Model of personality. *Personality and Individual Differences*, *91*, 154–158. https://doi.org/10.1016/j.paid.2015.11.054

Hanley, A. W., & Garland, E. L. (2017). The Mindful Personality: a Meta-analysis from a Cybernetic Perspective. *Mindfulness*, *8*(6), 1456–1470. https://doi.org/10.1007/s12671-017-0736-8

Hannigan, C., Brennan, S., Coen, R. F., Lawlor, B. A., & Robertson, I. H. (2013). Cognitive Reserve: Developing a model of the social processes that influence age-related cognitive decline. *Irish Journal of Medical Science*, *182*(6), S284.

Harada, C. N., Natelson Love, M. C., & Triebel, K. L. (2013). Normal Cognitive Aging. *Clinics in Geriatric Medicine*, *29*(4), 737–752. https://doi.org/10.1016/j.cger.2013.07.002

Harper, J., Malone, S. M., & Bernat, E. M. (2014). Theta and delta band activity explain N2 and P3 ERP component activity in a go/no-go task. *Clin Neurophysiol*, *125*(1), 124–132. https://doi.org/10.1016/j.clinph.2013.06.025

Harvey, L. A., & Close, J. C. (2012). Traumatic brain injury in older adults: characteristics, causes and consequences. *Injury*, *43*(11), 1821–1826. https://doi.org/10.1016/j.injury.2012.07.188

Hasenkamp, W., & Barsalou, L. W. (2012). Effects of Meditation Experience on Functional Connectivity of Distributed Brain Networks. *Frontiers in Human Neuroscience*, *6*. https://doi.org/10.3389/fnhum.2012.00038

Hayden, K. M., & Welsh-Bohmer, K. A. (2012). Epidemiology of cognitive aging and Alzheimer's disease: contributions of the cache county utah study of memory, health and aging. *Curr Top Behav Neurosci*, *10*, 3–31. https://doi.org/10.1007/7854_2011_152

Hayes, A. F., & Little, T. D. (2022). *Introduction to mediation, moderation, and conditional process analysis : a regression-based approach* (Third edition ed.). The Guilford Press.

He, B., Zhang, L., Zhuang, J.-H., Xu, J., Li, P., & Peng, H. (2019). The effects of different meditation exercises on sleep quality in older people: a network meta-analysis. *European Geriatric Medicine*, *10*(4), 543–552. https://doi.org/10.1007/s41999-019-00212-1

Heutz, R. A. M. (2017). Can Mindfulness Beat Alzheimer's Disease? *The Maastricht Journal of Liberal Arts*, *9*, 33–48.

Higgins, J., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M., & Welch, V. (2019). Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Handbook for Systematic Reviews of Interventions*. https://doi.org/10.1002/9781119536604

Hoch, C. C., Dew, M. A., Reynolds, C. F., Buysse, D. J., Nowell, P. D., Monk, T. H., Mazumdar, S., Borland, M. D., Miewald, J., & Kupfer, D. J. (1997).

Longitudinal changes in diary-and laboratory-based sleep measures in healthy “old old” and “young old” subjects: a three-year follow-up. *Sleep*, *20*(3), 192–202.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, *78*(2), 169–183. https://doi.org/10.1037/a0018555

Hölzel, B. K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S. M., Gard, T., & Lazar, S. W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry Research: Neuroimaging*, *191*(1), 36–43. https://doi.org/10.1016/j.pscychresns.2010.08.006

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How Does Mindfulness Meditation Work? Proposing Mechanisms of Action From a Conceptual and Neural Perspective. *Perspectives on Psychological Science*, *6*(6), 537–559. https://doi.org/10.1177/1745691611419671

Hölzel, B. K., Ott, U., Gard, T., Hempel, H., Weygandt, M., Morgen, K., & Vaitl, D. (2008). Investigation of mindfulness meditation practitioners with voxel-based morphometry. *Social Cognitive and Affective Neuroscience*, *3*(1), 55–61.

Horn, J. L., & Hofer, S. M. (1992). Major abilities and development in the adult period.

Horovitz, S. G., Braun, A. R., Carr, W. S., Picchioni, D., Balkin, T. J., Fukunaga, M., & Duyn, J. H. (2009). Decoupling of the brain's default mode network during deep sleep. *Proceedings of the National Academy of Sciences*, *106*(27), 11376–11381. https://doi.org/10.1073/pnas.0901435106

Howell, A. J., Digdon, N. L., Buro, K., & Sheptycki, A. R. (2008). Relations among mindfulness, well-being, and sleep. *Personality and Individual Differences*, *45*(8), 773–777. https://doi.org/https://doi.org/10.1016/j.paid.2008.08.005

Howieson, D. B., Holm, L. A., Kaye, J. A., Oken, B. S., & Howieson, J. (1993). Neurologic function in the optimally healthy oldest old. Neuropsychological evaluation. *Neurology*, *43*(10), 1882–1886. https://doi.org/10.1212/wnl.43.10.1882

Huang, J., Perrin, N. A., Spira, A. P., Szanton, S. L., Rebok, G. W., Budhathoki, C., Gooneratne, N. S., & Li, J. (2025). Sleep disturbance and cognitive trajectories among older adults with subjective cognitive decline: the roles of age and sleep treatment. *Sleep*. https://doi.org/10.1093/sleep/zsaf234

Hultsch, D. F., Hertzog, C., Small, B. J., & Dixon, R. A. (1999). Use it or lose it: engaged lifestyle as a buffer of cognitive decline in aging? *Psychol Aging*, *14*(2), 245–263. https://doi.org/10.1037//0882-7974.14.2.245

Jankowski, T., & Holas, P. (2014). Metacognitive model of mindfulness. *Consciousness and Cognition*, *28*, 64–80. https://doi.org/https://doi.org/10.1016/j.concog.2014.06.005

Jansen, W. J., Wilson, R. S., Visser, P. J., Nag, S., Schneider, J. A., James, B. D., Leurgans, S. E., Capuano, A. W., Bennett, D. A., & Boyle, P. A. (2018). Age and the association of dementia-related pathology with trajectories of cognitive decline. *Neurobiol Aging*, *61*, 138–145. https://doi.org/10.1016/j.neurobiolaging.2017.08.029

Jessen, F., Amariglio, R. E., Buckley, R. F., van der Flier, W. M., Han, Y., Molinuevo, J. L., Rabin, L., Rentz, D. M., Rodriguez-Gomez, O., Saykin, A. J., Sikkes, S. A. M., Smart, C. M., Wolfsgruber, S., & Wagner, M. (2020). The characterisation of subjective cognitive decline. *Lancet Neurol*, *19*(3), 271–278. https://doi.org/10.1016/s1474-4422(19)30368-0

Jessen, F., Amariglio, R. E., van Boxtel, M., Breteler, M., Ceccaldi, M., Chételat, G., Dubois, B., Dufouil, C., Ellis, K. A., van der Flier, W. M., Glodzik, L., van Harten, A. C., de Leon, M. J., McHugh, P., Mielke, M. M., Molinuevo, J. L., Mosconi, L., Osorio, R. S., Perrotin, A.,…Wagner, M. (2014). A conceptual framework for research on subjective cognitive decline in preclinical Alzheimer's disease. *Alzheimers Dement*, *10*(6), 844–852. https://doi.org/10.1016/j.jalz.2014.01.001

Jiang, H.-X., Xie, X., Xu, Y., Wang, R., Lei, X., & Yu, J. (2022). Older Adults' Subjective Cognitive Decline Correlated with Subjective but Not Objective Sleep: A Mediator Role of Depression. *The International Journal of Aging and Human Development*, *95*(1), 42–56. https://doi.org/10.1177/00914150211024186

John, A., Patel, U., Rusted, J., Richards, M., & Gaysina, D. (2019). Affective problems and decline in cognitive state in older adults: a systematic review and meta-analysis. *Psychological Medicine*, *49*(3), 353–365. https://doi.org/10.1017/s0033291718001137

Kabat-Zinn, J. (2013). *Full catastrophe living, revised edition: how to cope with stress, pain and illness using mindfulness meditation*. Hachette uK.

Kanen, J. W., Nazir, R., Sedky, K., & Pradhan, B. K. (2015). The Effects of Mindfulness-Based Interventions on Sleep Disturbance: A Meta-Analysis.

*Adolescent Psychiatry*, *5*(2), 105–115. https://doi.org/10.2174/2210676605666150311222928

Karl, J. A., Johnson, F. N., Bucci, L., & Fischer, R. (2022). In search of mindfulness: a review and reconsideration of cultural dynamics from a cognitive perspective. *J R Soc N Z*, *52*(2), 168–191. https://doi.org/10.1080/03036758.2021.1915804

Karsazi, H., Rezapour, T., Kormi-Nouri, R., Mottaghi, A., Abdekhodaie, E., & Hatami, J. (2021). The moderating effect of neuroticism and openness in the relationship between age and memory: Implications for cognitive reserve. *Personality and Individual Differences*, *176*, 110773.

Katsumi, Y., Howe, I. A., Eckbo, R., Wong, B., Quimby, M., Hochberg, D., Mcginnis, S. M., Putcha, D., Wolk, D. A., Touroutoglou, A., & Dickerson, B. C. (2024). *Default mode network tau predicts future clinical decline in atypical early Alzheimer's disease*. Cold Spring Harbor Laboratory.

Kaufman, A. S., & Horn, J. L. (1996). Age changes on tests of fluid and crystallized ability for women and men on the Kaufman Adolescent and Adult Intelligence Test (KAIT) at ages 17–94 years. *Archives of Clinical Neuropsychology*, *11*(2), 97–121.

Kaviani, H., & Hatami, N. (2016). Link between mindfulness and personality-related factors including empathy, theory of mind, openness, pro-social behaviour and suggestibility.

Kavousi, P., Mali, E., Seifhashemi, N., Souri, M., Pakravan, L., & Khalili, F. (2025). Worldwide Prevalence of Poor Sleep Quality in Older Adults: A Systematic Review and Meta-Analysis. *Iran J Psychiatry*, *20*(2), 265–280. https://doi.org/10.18502/ijps.v20i2.18207

Kelly, M. E., Duff, H., Kelly, S., Mchugh Power, J. E., Brennan, S., Lawlor, B. A., & Loughrey, D. G. (2017). The impact of social activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: a systematic review. *Systematic Reviews*, *6*(1). https://doi.org/10.1186/s13643-017-0632-2

Kelly, M. E., Loughrey, D., Lawlor, B. A., Robertson, I. H., Walsh, C., & Brennan, S. (2014a). The impact of cognitive training and mental stimulation on cognitive and everyday functioning of healthy older adults: a systematic review and meta-analysis. *Ageing Research Reviews*, *15*, 28–43.

Kelly, M. E., Loughrey, D., Lawlor, B. A., Robertson, I. H., Walsh, C., & Brennan, S. (2014b). The impact of exercise on the cognitive functioning of healthy older adults: a systematic review and meta-analysis. *Ageing Research Reviews*, *16*, 12–31.

Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research*, *78*(6), 519–528.

Kiken, L. G., Garland, E. L., Bluth, K., Palsson, O. S., & Gaylord, S. A. (2015). From a state to a trait: Trajectories of state mindfulness in meditation during intervention predict changes in trait mindfulness. *Personality and Individual Differences*, *81*, 41–46.

Killgore, W. D. S., Jankowski, S., Henderson-Arredondo, K., Lucas, D. A., Patel, S. I., Hildebrand, L. L., Huskey, A., & Dailey, N. S. (2023). Functional connectivity of the default mode network predicts subsequent polysomnographically measured sleep in people with symptoms of insomnia.

*Neuroreport*, *34*(14), 734–740. https://doi.org/10.1097/wnr.0000000000001949

Kim, J. H., Ahn, J. H., Min, C. Y., Yoo, D. M., & Choi, H. G. (2021). Association between sleep quality and subjective cognitive decline: evidence from a community health survey. *Sleep Med*, *83*, 123–131. https://doi.org/10.1016/j.sleep.2021.04.031

Kim, J. H., & Duffy, J. F. (2018). Circadian Rhythm Sleep-Wake Disorders in Older Adults. *Sleep Med Clin*, *13*(1), 39–50. https://doi.org/10.1016/j.jsmc.2017.09.004

Kim, S. M., Park, J. M., Seo, H.-J., Kim, J., Noh, J.-W., & Kim, H. L. (2022). Effects of mindfulness-based stress reduction on adults with sleep disturbance: an updated systematic review and meta-analysis. *BMJ Open*, *12*(11), e058032. https://doi.org/10.1136/bmjopen-2021-058032

Krell-Roesch, J., Lowe, V. J., Neureiter, J., Pink, A., Roberts, R. O., Mielke, M. M., Vemuri, P., Stokin, G. B., Christianson, T. J., Jack, C. R., Knopman, D. S., Boeve, B. F., Kremers, W. K., Petersen, R. C., Geda, Y. E., Mortby, M. E., & Ismail, Z. (2018). Depressive and anxiety symptoms and cortical amyloid deposition among cognitively normal elderly persons: the Mayo Clinic Study of Aging. *International Psychogeriatrics*, *30*(2), 245–251. https://doi.org/10.1017/s1041610217002368

Krueger, K. R., Wilson, R. S., Kamenetsky, J. M., Barnes, L. L., Bienias, J. L., & Bennett, D. A. (2009). Social Engagement and Cognitive Function in Old Age. *Experimental Aging Research*, *35*(1), 45–60. https://doi.org/10.1080/03610730802545028

Kubota, Y., Sato, W., Toichi, M., Murai, T., Okada, T., Hayashi, A., & Sengoku, A. (2001). Frontal midline theta rhythm is correlated with cardiac autonomic activities during the performance of an attention demanding meditation procedure. *Cognitive brain research*, *11*(2), 281–287.

Kuhn, E., Klinger, H. M., Amariglio, R. E., Wagner, M., Jessen, F., Düzel, E., Heneka, M. T., Chételat, G., Rentz, D. M., Sperling, R. A., Ebenau, J. L., Butterbrod, E., Van Der Flier, W. M., Sikkes, S. A. M., Teunnissen, C. E., Van Harten, A. C., Van De Giessen, E. M., Rami, L., Tort, A.,…Buckley, R. F. (2025). SCD-<i>plus</i> features and AD biomarkers in cognitively unimpaired samples: A meta-analytic approach for nine cohort studies. *Alzheimer's &amp; Dementia*, *21*(5). https://doi.org/10.1002/alz.14307

Kulkarni, S., O'Farrell, I., Erasi, M., & Kochar, M. S. (1998). Stress and hypertension. *Wmj*, *97*(11), 34–38.

Kurth, F., Cherbuin, N., & Luders, E. (2015). Reduced age-related degeneration of the hippocampal subiculum in long-term meditators. *Psychiatry Res*, *232*(3), 214–218. https://doi.org/10.1016/j.pscychresns.2015.03.008

Kurth, F., Cherbuin, N., & Luders, E. (2017). Aging Mindfully to Minimize Cognitive Decline. *Journal of Cognitive Enhancement*, *1*(2), 108–114. https://doi.org/10.1007/s41465-017-0027-2

Lam, L. C. W., Lee, A. T. C., Cheng, S. T., Yip, B. H. K., Chan, W. C., Fung, A. W. T., Ma, S. L., Cheng, C. P. W., Kong, R., Chiu, H. T. S., Lai, F. H. Y., & Wong, S. Y. S. (2021). Mindfulness Awareness Is Associated With a Lower Risk of Anxiety and Depressive Symptoms in Older Adults With Neurocognitive Disorders. *Front Psychiatry*, *12*, 721583. https://doi.org/10.3389/fpsyt.2021.721583

Landry, G. J., Best, J. R., & Liu-Ambrose, T. (2015). Measuring sleep quality in older adults: a comparison using subjective and objective methods. *Frontiers in Aging Neuroscience*, *7*. https://doi.org/10.3389/fnagi.2015.00166

Lannon-Boran, C., Hannigan, C., Power, J. M., Lambert, J., & Kelly, M. (2023). The effect of mindfulness-based intervention on cognitively unimpaired older adults' cognitive function and sleep quality: a systematic review and meta-analysis. *Aging & mental health*, 1–13. https://doi.org/10.1080/13607863.2023.2228255

Lauriola, M., Esposito, R., de Zambotti, M., Londrillo, F., Rabinovici, G. D., Kramer, J., & Tartaro, A. (2016). O2-04-04: Disrupted Sleep in Subjective Cognitive Decline. *Alzheimer's & Dementia*, *12*(7S_Part_4), P230–P231. https://doi.org/https://doi.org/10.1016/j.jalz.2016.06.414

Lee, D., Park, J. Y., & Kim, W. J. (2023). Altered functional connectivity of the default mode and dorsal attention network in subjective cognitive decline. *J Psychiatr Res*, *159*, 165–171. https://doi.org/10.1016/j.jpsychires.2023.01.040

Lee, J. E., Ju, Y. J., Park, E. C., & Lee, S. Y. (2020). Effect of poor sleep quality on subjective cognitive decline (SCD) or SCD-related functional difficulties: Results from 220,000 nationwide general populations without dementia. *J Affect Disord*, *260*, 32–37. https://doi.org/10.1016/j.jad.2019.08.082

Leng, M., Yin, H., Zhang, P., Jia, Y., Hu, M., Li, G., Wang, C., & Chen, L. (2020). Sleep Quality and Health-Related Quality of Life in Older People With Subjective Cognitive Decline, Mild Cognitive Impairment, and Alzheimer Disease. *J Nerv Ment Dis*, *208*(5), 387–396. https://doi.org/10.1097/nmd.0000000000001137

Lenze, E. J., Hickman, S., Hershey, T., Wendleton, L., Ly, K., Dixon, D., Doré, P., & Wetherell, J. L. (2014). Mindfulness-based stress reduction for older adults with worry symptoms and co-occurring cognitive dysfunction. *International Journal of Geriatric Psychiatry*, *29*(10), 991–1000. https://doi.org/10.1002/gps.4086

Li, H., Tan, C.-C., Tan, L., & Xu, W. (2023). Predictors of cognitive deterioration in subjective cognitive decline: evidence from longitudinal studies and implications for SCD-plus criteria. *Journal of Neurology, Neurosurgery &amp;amp; Psychiatry*, *94*(10), 844. https://doi.org/10.1136/jnnp-2022-330246

Li, Y., Tang, J., & Chen, G. (2025). The Effect of Meditation-Based Mind-Body Interventions on Older Adults with Poor Sleep Quality: A Meta-Analysis of Randomized Controlled Trials. *Behavioral sleep medicine*, *23*(3), 341–359. https://doi.org/10.1080/15402002.2025.2475911

Li, Y., Zhang, X., Winkelman, J. W., Redline, S., Hu, F. B., Stampfer, M., Ma, J., & Gao, X. (2014). Association between insomnia symptoms and mortality: a prospective study of US men. *Circulation*, *129*(7), 737–746.

Lim, A. S. P., Kowgier, M., Yu, L., Buchman, A. S., & Bennett, D. A. (2013). Sleep Fragmentation and the Risk of Incident Alzheimer's Disease and Cognitive Decline in Older Persons. *Sleep*, *36*(7), 1027–1032. https://doi.org/10.5665/sleep.2802

Lim, E. Y., Shim, Y. S., Hong, Y. J., Ryu, S. Y., Cho, A. H., & Yang, D. W. (2019). Different Cortical Thinning Patterns Depending on Their Prognosis in Individuals with Subjective Cognitive Decline. *Dementia and Neurocognitive Disorders*, *18*(4), 113. https://doi.org/10.12779/dnd.2019.18.4.113

Lin, R., Su, J., & Heffner, K. (2023). EFFECTS OF MINDFULNESS ON COGNITION IN ADULTS WITH MILD COGNITIVE IMPAIRMENT: A META-ANALYSIS. *Innovation in Aging*, *7*(Supplement_1), 633–633. https://doi.org/10.1093/geroni/igad104.2062

Lindsay, E. K., Chin, B., Greco, C. M., Young, S., Brown, K. W., Wright, A. G. C., Smyth, J. M., Burkett, D., & Creswell, J. D. (2018). How mindfulness training promotes positive emotions: Dismantling acceptance skills training in two randomized controlled trials. *J Pers Soc Psychol*, *115*(6), 944–973. https://doi.org/10.1037/pspa0000134

Lindsay, E. K., & Creswell, J. D. (2017). Mechanisms of mindfulness training: Monitor and Acceptance Theory (MAT). *Clinical Psychology Review*, *51*, 48–59. https://doi.org/10.1016/j.cpr.2016.10.011

Lindsay, E. K., & Creswell, J. D. (2019). Mindfulness, acceptance, and emotion regulation: perspectives from Monitor and Acceptance Theory (MAT). *Curr Opin Psychol*, *28*, 120–125. https://doi.org/10.1016/j.copsyc.2018.12.004

Lindsay, E. K., Creswell, J. D., Stern, H. J., Greco, C. M., Walko, T. D., Dutcher, J. M., Wright, A. G. C., Brown, K. W., & Marsland, A. L. (2022). Mindfulness-based stress reduction increases stimulated IL-6 production among lonely older adults: A randomized controlled trial. *Brain Behav Immun*, *104*, 6–15. https://doi.org/10.1016/j.bbi.2022.05.001

Lindsay, E. K., Young, S., Brown, K. W., Smyth, J. M., & Creswell, J. D. (2019). Mindfulness training reduces loneliness and increases social contact in a randomized controlled trial. *Proceedings of the National Academy of Sciences*, *116*(9), 3488–3493. https://doi.org/10.1073/pnas.1813588116

Liou, C.-H., Hsieh, C.-W., Hsieh, C.-H., Lee, S.-C., Chen, J.-H., & Wang, C.-H. (2007). Correlation between pineal activation and religious meditation observed by functional magnetic resonance imaging. *Nature Precedings*, 1–1.

Lista, S., & Hampel, H. (2017). Synaptic degeneration and neurogranin in the pathophysiology of Alzheimer's disease. *Expert Rev Neurother*, *17*(1), 47–57. https://doi.org/10.1080/14737175.2016.1204234

Liu, M. Y., Li, N., Li, W. A., & Khan, H. (2017). Association between psychosocial stress and hypertension: a systematic review and meta-analysis. *Neurol Res*, *39*(6), 573–580. https://doi.org/10.1080/01616412.2017.1317904

Liu, T., Spector, A., Mograbi, D. C., Cheung, G., & Wong, G. H. Y. (2021). Changes in Default Mode Network Connectivity in Resting-State fMRI in People with Mild Dementia Receiving Cognitive Stimulation Therapy. *Brain Sci*, *11*(9). https://doi.org/10.3390/brainsci11091137

Livingston, G., Huntley, J., Liu, K. Y., Costafreda, S. G., Selbæk, G., Alladi, S., Ames, D., Banerjee, S., Burns, A., Brayne, C., Fox, N. C., Ferri, C. P., Gitlin, L. N., Howard, R., Kales, H. C., Kivimäki, M., Larson, E. B., Nakasujja, N., Rockwood, K.,…Mukadam, N. (2024). Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. *The Lancet*, *404*(10452), 572–628. https://doi.org/10.1016/S0140-6736(24)01296-0

López-Higes, R., Rubio-Valdehita, S., Fernandes, S. M., & Rodrigues, P. F. S. (2024). Differentiation between Normal Cognition and Subjective Cognitive Decline in Older Adults Using Discrepancy Scores Derived from Neuropsychological Tests. *Geriatrics*, *9*(3), 83. https://doi.org/10.3390/geriatrics9030083

Lorig, K., Holman, H., & Sobel, D. (2013). *Living a healthy life with chronic conditions: for ongoing physical and mental health conditions*. Bull Publishing Company.

Luders, E., Cherbuin, N., & Gaser, C. (2016). Estimating brain age using high-resolution pattern recognition: Younger brains in long-term meditation practitioners. *NeuroImage*, *134*, 508–513. https://doi.org/10.1016/j.neuroimage.2016.04.007

Luders, E., Clark, K., Narr, K. L., & Toga, A. W. (2011). Enhanced brain connectivity in long-term meditation practitioners. *NeuroImage*, *57*(4), 1308–1316. https://doi.org/10.1016/j.neuroimage.2011.05.075

Luders, E., Toga, A. W., Lepore, N., & Gaser, C. (2009). The underlying anatomical correlates of long-term meditation: larger hippocampal and frontal volumes of gray matter. *NeuroImage*, *45*(3), 672–678. https://doi.org/10.1016/j.neuroimage.2008.12.061

Luszcz, M. A., & Bryan, J. (1999). Toward understanding age-related memory loss in late adulthood. *Gerontology*, *45*(1), 2–9. https://doi.org/10.1159/000022048

Lutz, A., Chételat, G., Collette, F., Klimecki, O. M., Marchant, N. L., & Gonneaud, J. (2021). The protective effect of mindfulness and compassion meditation practices on ageing: Hypotheses, models and experimental implementation. *Ageing Research Reviews*, *72*, 101495. https://doi.org/10.1016/j.arr.2021.101495

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in cognitive sciences*, *12*(4), 163–169.

Lutz, A., Slagter, H. A., Rawlings, N. B., Francis, A. D., Greischar, L. L., & Davidson, R. J. (2009). Mental training enhances attentional stability: neural and behavioral evidence. *J Neurosci*, *29*(42), 13418–13427. https://doi.org/10.1523/jneurosci.1614-09.2009

Ma, S. H., & Teasdale, J. D. (2004). Mindfulness-based cognitive therapy for depression: replication and exploration of differential relapse prevention effects. *J Consult Clin Psychol*, *72*(1), 31–40. https://doi.org/10.1037/0022-006x.72.1.31

Ma, Y., Liang, L., Zheng, F., Shi, L., Zhong, B., & Xie, W. (2020). Association Between Sleep Duration and Cognitive Decline. *JAMA Network Open*, *3*(9), e2013573. https://doi.org/10.1001/jamanetworkopen.2020.13573

MacAulay, R. K., Brown, L. F., & Moore, L. (2023). Mindfulness stress-buffering model of health: implications for successful aging. *Aging Ment Health*, *27*(8), 1592–1599. https://doi.org/10.1080/13607863.2022.2107175

MacAulay, R. K., Halpin, A., Andrews, H. E., & Boeve, A. (2022). Trait mindfulness associations with executive function and well-being in older adults. *Aging Ment Health*, *26*(12), 2399–2406. https://doi.org/10.1080/13607863.2021.1998352

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation Analysis. *Annual review of psychology*, *58*(1), 593–614. https://doi.org/10.1146/annurev.psych.58.110405.085542

MacLeod, C. M., & MacDonald, P. A. (2000). Interdimensional interference in the Stroop effect: uncovering the cognitive and neural anatomy of attention. *Trends Cogn Sci*, *4*(10), 383–391. https://doi.org/10.1016/s1364-6613(00)01530-8

MacLeod, S., Musich, S., Kraemer, S., & Wicker, E. (2018). Practical non-pharmacological intervention approaches for sleep problems among older adults. *Geriatric Nursing*, *39*(5), 506–512. https://doi.org/10.1016/j.gerinurse.2018.02.002

Mahendran, R., Chua, J., Feng, L., Kua, E. H., & Preedy, V. R. (2015). Chapter 109 - The Mini-Mental State Examination and Other Neuropsychological Assessment Tools for Detecting Cognitive Decline. In C. R. Martin & V. R. Preedy (Eds.), *Diet and Nutrition in Dementia and Cognitive Decline* (pp. 1159–1174). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-407824-6.00109-9

Maki, P. M., & Henderson, V. W. (2016). Cognition and the menopause transition. *Menopause*, *23*(7), 803–805. https://doi.org/10.1097/gme.0000000000000681

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience*, *7*. https://doi.org/10.3389/fnins.2013.00008

Malinowski, P., Moore, A. W., Mead, B. R., & Gruber, T. (2017). Mindful Aging: The Effects of Regular Brief Mindfulness Practice on Electrophysiological Markers of Cognitive and Affective Processing in Older Adults. *Mindfulness*, *8*(1), 78–94. https://doi.org/10.1007/s12671-015-0482-8

Malinowski, P., & Shalamanova, L. (2017). Meditation and Cognitive Ageing: the Role of Mindfulness Meditation in Building Cognitive Reserve. *Journal of Cognitive Enhancement*, *1*(2), 96–106. https://doi.org/10.1007/s41465-017-0022-7

Mallya, S., & Fiocco, A. J. (2016). Effects of Mindfulness Training on Cognition and Well-Being in Healthy Older Adults. *Mindfulness*, *7*(2), 453–465. https://doi.org/10.1007/s12671-015-0468-6

Mander, B. A., Rao, V., Lu, B., Saletin, J. M., Lindquist, J. R., Ancoli-Israel, S., Jagust, W., & Walker, M. P. (2013). Prefrontal atrophy, disrupted NREM slow waves and impaired hippocampal-dependent memory in aging. *Nature neuroscience*, *16*(3), 357–364.

Mander, B. A., Winer, J. R., & Walker, M. P. (2017). Sleep and human aging. *Neuron*, *94*(1), 19–36.

Mangialasche, F., Kivipelto, M., Solomon, A., & Fratiglioni, L. (2012). Dementia prevention: current epidemiological evidence and future perspective. *Alzheimers Res Ther*, *4*(1), 6. https://doi.org/10.1186/alzrt104

Marchant, L., Natalie, Barnhofer, T., Coueron, R., Wirth, M., Lutz, A., Arenaza-Urquijo, M., Eider, Collette, F., Poisnel, G., Demnitz-King, H., Schild, A.-K., Coll-Padros, N., Delphin-Combe, F., Whitfield, T., Schlosser, M., Gonneaud, J., Asselineau, J., Walker, Z., Krolak-Salmon, P., Molinuevo, L., José,…Klimecki, M., Olga. (2021). Effects of a Mindfulness-Based Intervention versus Health Self-Management on Subclinical Anxiety in Older Adults with Subjective Cognitive Decline: The SCD-Well Randomized Superiority Trial. *Psychotherapy and Psychosomatics*, *90*(5), 341–350. https://doi.org/10.1159/000515669

Marchant, N. L., Barnhofer, T., Klimecki, O. M., Poisnel, G., Lutz, A., Arenaza-Urquijo, E., Collette, F., Wirth, M., Schild, A. K., Coll-Padrós, N., Reyrolle, L., Horney, D., Krolak-Salmon, P., Molinuevo, J. L., Walker, Z., Maillard, A., Frison, E., Jessen, F., Chételat, G.,…Wingrove, J. (2018). The SCD-Well randomized controlled trial: Effects of a mindfulness-based intervention versus health education on mental health in patients with subjective cognitive decline (SCD). *Alzheimer's & Dementia: Translational Research & Clinical Interventions*, *4*(1), 737–745. https://doi.org/10.1016/j.trci.2018.10.010

Marciniak, R., Sheardova, K., Čermáková, P., Hudeček, D., Šumec, R., & Hort, J. (2014). Effect of meditation on cognitive functions in context of aging and neurodegenerative diseases [Review]. *Frontiers in Behavioral Neuroscience*, *8*(JAN). https://doi.org/10.3389/fnbeh.2014.00017

Marques, D. R., Gomes, A. A., Clemente, V., Dos Santos, J. M., Duarte, I. C., Caetano, G., & Castelo-Branco, M. (2018). Self-Referential Dysfunction and Default-Mode Hyperactivation in Psychophysiological Insomnia Patients. *Journal of Psychophysiology*, *32*(3), 140–155. https://doi.org/10.1027/0269-8803/a000194

Marques, D. R., Gomes, A. A., Clemente, V., Moutinho Dos Santos, J., & Castelo-Branco, M. (2015). Default-mode network activity and its role in comprehension and management of psychophysiological insomnia: A new perspective. *New Ideas in Psychology*, *36*, 30–37. https://doi.org/10.1016/j.newideapsych.2014.08.001

Martin, M., Clare, L., Altgassen, A. M., Cameron, M. H., & Zehnder, F. (2011). Cognition-based interventions for healthy older people and people with mild cognitive impairment. *Cochrane database of systematic reviews*(1).

Marzetti, L., Di Lanzo, C., Zappasodi, F., Chella, F., Raffone, A., & Pizzella, V. (2014). Magnetoencephalographic alpha band connectivity reveals differential default mode network interactions during focused attention and open monitoring meditation [Original Research]. *Frontiers in Human Neuroscience*, *8*(832). https://doi.org/10.3389/fnhum.2014.00832

Mascherek, A., Werkle, N., Göritz, A. S., Kühn, S., & Moritz, S. (2020). Lifestyle Variables Do Not Predict Subjective Memory Performance Over and Above Depression and Anxiety [Original Research]. *Frontiers in Psychology*, *Volume 11 - 2020*. https://doi.org/10.3389/fpsyg.2020.00484

Mattis, S. (1988). Dementia Rating Scale (DRS): Professional Manual. *Psychological Assemssment Resources*.

McCall, C. A., & Watson, N. F. (2021). Chapter 7 - Sleep, neurocognition, and aging, including secular trends in older adult sleep. In K. W. Schaie & S. L. Willis (Eds.), *Handbook of the Psychology of Aging (Ninth Edition)* (pp. 99–117). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-816094-7.00005-2

McEwen, B. S., & Sapolsky, R. M. (1995). Stress and cognitive function. *Curr Opin Neurobiol*, *5*(2), 205–216. https://doi.org/10.1016/0959-4388(95)80028-x

McGilchrist, I. (2019). *The master and his emissary: The divided brain and the making of the western world*. Yale University Press.

McNair, D. M., & Kahn, R. J. (1983). Self-assessment of cognitive deficits. *Assessment in geriatric psychopharmacology*, *137*, 143.

Mengel, D., Soter, E., Ott, J. M., Wacker, M., Leyva, A., Peters, O., Hellmann-Regen, J., Schneider, L.-S., Wang, X., Priller, J., Spruth, E., Altenstein, S., Schneider, A., Fliessbach, K., Wiltfang, J., Hansen, N., Rostamzadeh, A., Düzel, E., Glanz, W.,…Synofzik, M. (2024). *Blood biomarkers confirm subjective cognitive decline (SCD) as a distinct molecular and clinical stage* *within the NIA-AA framework of Alzheimer's disease*. Cold Spring Harbor Laboratory.

Mitchell, A. J., Beaumont, H., Ferguson, D., Yadegarfar, M., & Stubbs, B. (2014). Risk of dementia and mild cognitive impairment in older people with subjective memory complaints: meta-analysis. *Acta Psychiatrica Scandinavica*, *130*(6), 439–451.

Mohanty, M., & Kumar, P. (2022). Multi-Component Interventions in Older Adults Having Subjective Cognitive Decline (SCD)—A Review Article. *Geriatrics*, *8*(1), 4. https://doi.org/10.3390/geriatrics8010004

Monisha, S., Roy, D., Menon, A. J., Gandhi, S., Gupta, A., Basavaraju, N., Singh, S., Sundarakumar, J., Kommaddi, R., & Issac, T. (2025). Exploring predementia: Understanding the characteristics of subjective cognitive decline plus from India. *Journal of Alzheimer's Disease*, *103*, 966–973. https://doi.org/10.1177/13872877241307344

Monteiro, J. M., Gonçalves, R., Bastos, A., & Barbosa, M. R. (2024). Social engagement and wellbeing in late life: a systematic review. *Ageing and Society*, 1–28. https://doi.org/10.1017/S0144686X24000011

Moreno, D. S. E. (2019). *Mindfulness-based cognitive therapy intervention for the treatment of late-life depression and anxiety symptoms in primary care: a randomized controlled trial*. McGill University (Canada).

Morone, N. E., Lynch, C. S., Greco, C. M., Tindle, H. A., & Weiner, D. K. (2008). "I Felt Like a New Person." The Effects of Mindfulness Meditation on Older Adults With Chronic Pain: Qualitative Narrative Analysis of Diary Entries. *The Journal of Pain*, *9*(9), 841–848. https://doi.org/10.1016/j.jpain.2008.04.003

Moynihan, J. A., Chapman, B. P., Klorman, R., Krasner, M. S., Duberstein, P. R., Brown, K. W., & Talbot, N. L. (2013). Mindfulness-based stress reduction for older adults: effects on executive function, frontal alpha asymmetry and immune function. *Neuropsychobiology*, *68*(1), 34–43. https://doi.org/10.1159/000350949

Munro, C. E., Boyle, R., Chen, X., Coughlan, G., Gonzalez, C., Jutten, R. J., Martinez, J., Orlovsky, I., Robinson, T., Weizenbaum, E., Pluim, C. F., Quiroz-Gaviria, Y. T., Gatchel, J. R., Vannini, P., & Amariglio, R. (2023). Recent contributions to the field of subjective cognitive decline in aging: A literature review. *Alzheimers Dement (Amst)*, *15*(4), e12475. https://doi.org/10.1002/dad2.12475

Neikrug, A. B., & Ancoli-Israel, S. (2010). Sleep disorders in the older adult–a mini-review. *Gerontology*, *56*(2), 181–189.

Nyberg, L. (2017). Functional brain imaging of episodic memory decline in ageing. *Journal of Internal Medicine*, *281*(1), 65–74. https://doi.org/10.1111/joim.12533

O'Donnell, D., Silva, E. J., Münch, M., Ronda, J. M., Wang, W., & Duffy, J. F. (2009). Comparison of subjective and objective assessments of sleep in healthy older subjects without sleep complaints. *Journal of Sleep Research*, *18*(2), 254–263. https://doi.org/10.1111/j.1365-2869.2008.00719.x

Oken, B. S., Wahbeh, H., Goodrich, E., Klee, D., Memmott, T., Miller, M., & Fu, R. W. (2017). Meditation in Stressed Older Adults: Improvements in Self-Rated Mental Health Not Paralleled by Improvements in Cognitive Function or Physiological Measures. *Mindfulness*, *8*(3), 627–638. https://doi.org/10.1007/s12671-016-0640-7

Ong, J. C., Manber, R., Segal, Z., Xia, Y., Shapiro, S., & Wyatt, J. K. (2014). A Randomized Controlled Trial of Mindfulness Meditation for Chronic Insomnia. *Sleep*, *37*(9), 1553–1563. https://doi.org/10.5665/sleep.4010

Ossenkoppele, R., Jansen, W. J., Rabinovici, G. D., Knol, D. L., van der Flier, W. M., van Berckel, B. N., Scheltens, P., Visser, P. J., Verfaillie, S. C., Zwan, M. D., Adriaanse, S. M., Lammertsma, A. A., Barkhof, F., Jagust, W. J., Miller, B. L., Rosen, H. J., Landau, S. M., Villemagne, V. L., Rowe, C. C.,…Brooks, D. J. (2015). Prevalence of amyloid PET positivity in dementia syndromes: a meta-analysis. *JAMA*, *313*(19), 1939–1949. https://doi.org/10.1001/jama.2015.4669

Ostafin, B., & Marlatt, G. (2008). Surfing the Urge: Experiential Acceptance Moderates the Relation Between Automatic Alcohol Motivation and Hazardous Drinking. *Journal of Social and Clinical Psychology - J SOC CLIN PSYCHOL*, *27*, 404–418. https://doi.org/10.1521/jscp.2008.27.4.404

Pace-Schott, E. F., & Spencer, R. M. (2011). Age-related changes in the cognitive function of sleep. *Prog Brain Res*, *191*, 75–89. https://doi.org/10.1016/b978-0-444-53752-2.00012-6

Pagnoni, G., & Cekic, M. (2007). Age effects on gray matter volume and attentional performance in Zen meditation. *Neurobiology of Aging*, *28*(10), 1623–1627.

Palmqvist, S., Schöll, M., Strandberg, O., Mattsson, N., Stomrud, E., Zetterberg, H., Blennow, K., Landau, S., Jagust, W., & Hansson, O. (2017). Earliest accumulation of β-amyloid occurs within the default-mode network and concurrently affects brain connectivity. *Nature Communications*, *8*(1). https://doi.org/10.1038/s41467-017-01150-x

Park, S. H., & Han, K. S. (2017). Blood Pressure Response to Meditation and Yoga: A Systematic Review and Meta-Analysis. *J Altern Complement Med*, *23*(9), 685–695. https://doi.org/10.1089/acm.2016.0234

Park, T., Reilly-Spong, M., & Gross, C. R. (2013). Mindfulness: a systematic review of instruments to measure an emergent patient-reported outcome (PRO). *Quality of Life Research*, *22*(10), 2639–2659.

Patterson, C. (2018). *World Alzheimer report 2018* [Report]. Alzheimer's Disease International.

Pavel, A., Matei, V., Paun, R., & Tudose, C. (2022). How "Subjective" is Subjective Cognitive Decline? *Psychiatry Clin Psychopharmacol*, *32*(4), 299–305. https://doi.org/10.5152/pcp.2022.22506

Pedraza, O., Lucas, J. A., Smith, G. E., Petersen, R. C., Graff-Radford, N. R., & Ivnik, R. J. (2010). Robust and Expanded Norms for the Dementia Rating Scale. *Archives of Clinical Neuropsychology*, *25*(5), 347–358. https://doi.org/10.1093/arclin/acq030

Pernet, C. R., Belov, N., Delorme, A., & Zammit, A. (2021). Mindfulness related changes in grey matter: a systematic review and meta-analysis. *Brain Imaging and Behavior*, *15*(5), 2720–2730. https://doi.org/10.1007/s11682-021-00453-4

Petersen, R. C. (2004). Mild cognitive impairment. *CONTINUUM: Lifelong Learning in Neurology*, *10*(1), 9–28.

Petersen, R. C., Caracciolo, B., Brayne, C., Gauthier, S., Jelic, V., & Fratiglioni, L. (2014). Mild cognitive impairment: a concept in evolution. *Journal of Internal Medicine*, *275*(3), 214–228. https://doi.org/10.1111/joim.12190

Pietrzak, R. H., Lim, Y. Y., Neumeister, A., Ames, D., Ellis, K. A., Harrington, K., Lautenschlager, N. T., Restrepo, C., Martins, R. N., Masters, C. L., Villemagne, V. L., Rowe, C. C., Maruff, P., for the Australian Imaging, B., & Group, L. R. (2015). Amyloid-β, Anxiety, and Cognitive Decline in Preclinical Alzheimer Disease: A Multicenter, Prospective Cohort Study. *JAMA Psychiatry*, *72*(3), 284–291. https://doi.org/10.1001/jamapsychiatry.2014.2476

Pihlajamäki, M., Tanila, H., Hänninen, T., Könönen, M., Laakso, M., Partanen, K., Soininen, H., & Aronen, H. J. (2000). Verbal fluency activates the left medial temporal lobe: a functional magnetic resonance imaging study. *Annals of Neurology: Official Journal of the American Neurological Association and the Child Neurology Society*, *47*(4), 470–476.

Pink, A., Krell-Roesch, J., Syrjanen, J. A., Vassilaki, M., Lowe, V. J., Vemuri, P., Stokin, G. B., Christianson, T. J., Kremers, W. K., Jack, C. R., Knopman, D. S., Petersen, R. C., & Geda, Y. E. (2022). A longitudinal investigation of Aβ, anxiety, depression, and mild cognitive impairment. *Alzheimer's & Dementia*, *18*(10), 1824–1831. https://doi.org/https://doi.org/10.1002/alz.12504

Polsinelli, A. J., Kaszniak, A. W., Glisky, E. L., & Ashish, D. (2020). Effects of a Brief, Online, Focused Attention Mindfulness Training on Cognition in Older Adults: a Randomized Controlled Trial. *Mindfulness*, *11*(5), 1182–1193. https://doi.org/10.1007/s12671-020-01329-2

Porter, V. R., Buxton, W. G., & Avidan, A. Y. (2015). Sleep, cognition and dementia. *Current Psychiatry Reports*, *17*(12), 1–11.

Potvin, O., Lorrain, D., Forget, H., Dubé, M., Grenier, S., Préville, M., & Hudon, C. (2012). Sleep quality and 1-year incident cognitive impairment in community-dwelling older adults. *Sleep*, *35*(4), 491–499. https://doi.org/10.5665/sleep.1732

Prakash, R., Rastogi, P., Dubey, I., Abhishek, P., Chaudhury, S., & Small, B. J. (2012). Long-term concentrative meditation and cognitive performance among older adults. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn*, *19*(4), 479–494. https://doi.org/10.1080/13825585.2011.630932

Prakash, R. S., Hussain, M. A., & Schirda, B. (2015). The role of emotion regulation and cognitive control in the association between mindfulness disposition and stress. *Psychol Aging*, *30*(1), 160–171. https://doi.org/10.1037/a0038544

Pscherer, C., Mückschel, M., Bluschke, A., & Beste, C. (2022). Resting-state theta activity is linked to information content-specific coding levels during response inhibition. *Sci Rep*, *12*(1), 4530. https://doi.org/10.1038/s41598-022-08510-8

Pulopulos, M. M., Hidalgo, V., Puig-Perez, S., Montoliu, T., & Salvador, A. (2020). Relationship between Cortisol Changes during the Night and Subjective and Objective Sleep Quality in Healthy Older People. *Int J Environ Res Public Health*, *17*(4). https://doi.org/10.3390/ijerph17041264

Quaglia, J. T., Goodman, R. J., & Brown, K. W. (2015). From mindful attention to social connection: The key role of emotion regulation. *Cognition and Emotion*, *29*(8), 1466–1474. https://doi.org/10.1080/02699931.2014.988124

Querstret, D., Morison, L., Dickinson, S., Cropley, M., & John, M. (2020). Mindfulness-based stress reduction and mindfulness-based cognitive therapy for psychological health and well-being in nonclinical samples: A systematic review and meta-analysis. *International Journal of Stress Management*, *27*(4), 394–411. https://doi.org/10.1037/str0000165

Quintana-Hernández, D. J., Miró-Barrachina, M. T., Ibáñez-Fernández, I. J., Pino, A. S.-d., Quintana-Montesdeoca, M. P., Rodríguez-de Vera, B., Morales-Casanova, D., Pérez-Vieitez, M. d. C., Rodríguez-García, J., & Bravo-Caraduje, N. (2016). Mindfulness in the maintenance of cognitive capacities in Alzheimer’s disease: A randomized clinical trial. *Journal of Alzheimer's Disease*, *50*(1), 217–232. https://doi.org/10.3233/JAD-143009

Rahrig, H., Vago, D. R., Passarelli, M. A., Auten, A., Lynn, N. A., & Brown, K. W. (2022). Meta-analytic evidence that mindfulness training alters resting state default mode network connectivity. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-15195-6

Raichle, M. E. (2015). The brain's default mode network. *Annu Rev Neurosci*, *38*, 433–447. https://doi.org/10.1146/annurev-neuro-071013-014030

Rainforth, M. V., Schneider, R. H., Nidich, S. I., Gaylord-King, C., Salerno, J. W., & Anderson, J. W. (2007). Stress reduction programs in patients with elevated blood pressure: a systematic review and meta-analysis. *Curr Hypertens Rep*, *9*(6), 520–528. https://doi.org/10.1007/s11906-007-0094-3

Raz, N. (2000). Aging of the brain and its impact on cognitive performance: Integration of structural and functional findings. In *The handbook of aging and cognition, 2nd ed.* (pp. 1–90). Lawrence Erlbaum Associates Publishers.

Reangsing, C., Rittiwong, T., & Schneider, J. K. (2021). Effects of mindfulness meditation interventions on depression in older adults: A meta-analysis. *Aging & mental health*, *25*(7), 1181–1190.

Regen, W., Kyle, S. D., Nissen, C., Feige, B., Baglioni, C., Hennig, J., Riemann, D., & Spiegelhalder, K. (2016). Objective sleep disturbances are associated with greater waking resting-state connectivity between the retrosplenial cortex/hippocampus and various nodes of the default mode network. *Journal of Psychiatry and Neuroscience*, *41*(5), 295–303. https://doi.org/10.1503/jpn.140290

Reisberg, B., Prichep, L., Mosconi, L., John, E. R., Glodzik-Sobanska, L., Boksay, I., Monteiro, I., Torossian, C., Vedvyas, A., Ashraf, N., Jamil, I. A., & de Leon, M. J. (2008). The pre–mild cognitive impairment, subjective cognitive impairment stage of Alzheimer's disease. *Alzheimer's & Dementia*, *4*(1S1), S98–S108. https://doi.org/https://doi.org/10.1016/j.jalz.2007.11.017

Reisberg, B., Shulman, M. B., Torossian, C., Leng, L., & Zhu, W. (2010). Outcome over seven years of healthy adults with and without subjective cognitive impairment. *Alzheimers Dement*, *6*(1), 11–24. https://doi.org/10.1016/j.jalz.2009.10.002

Reuter-Lorenz, P. A., & Cappell, K. A. (2008). Neurocognitive aging and the compensation hypothesis. *Current directions in psychological science*, *17*(3), 177–182.

Reuter-Lorenz, P. A., Festini, S. B., & Jantz, T. K. (2021). Chapter 5 - Executive functions and neurocognitive aging. In K. W. Schaie & S. L. Willis (Eds.), *Handbook of the Psychology of Aging (Ninth Edition)* (pp. 67–81). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-816094-7.00019-2

Reuter, E.-M., Vieluf, S., Koutsandreou, F., Hübner, L., Budde, H., Godde, B., & Voelcker-Rehage, C. (2019). A non-linear relationship between selective attention and associated ERP markers across the lifespan. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.00030

Reynolds, G. O., Willment, K., & Gale, S. A. (2021). Mindfulness and Cognitive Training Interventions in Mild Cognitive Impairment: Impact on Cognition and Mood. *Am J Med*, *134*(4), 444–455. https://doi.org/10.1016/j.amjmed.2020.10.041

Rivas-Fernández, M. Á., Lindín, M., Zurrón, M., Díaz, F., Lojo-Seoane, C., Pereiro, A. X., & Galdo-Álvarez, S. (2023). Neuroanatomical and neurocognitive changes associated with subjective cognitive decline. *Frontiers in Medicine*, *10*. https://doi.org/10.3389/fmed.2023.1094799

Robertson, I. H. (2014). A right hemisphere role in cognitive reserve. *Neurobiology of Aging*, *35*(6), 1375–1385. https://doi.org/10.1016/j.neurobiolaging.2013.11.028

Rodríguez, D., Ayers, E., Weiss, E. F., & Verghese, J. (2021). Cross-Cultural Comparisons of Subjective Cognitive Complaints in a Diverse Primary Care Population. *J Alzheimers Dis*, *81*(2), 545–555. https://doi.org/10.3233/jad-201399

Rog, L. A., & Fink, J. W. (2013). Mild cognitive impairment and normal aging. In *Handbook on the Neuropsychology of Aging and Dementia* (pp. 239–256). Springer.

Roheger, M., Hennersdorf, X. S., Riemann, S., Flöel, A., & Meinzer, M. (2021). A systematic review and network meta-analysis of interventions for subjective cognitive decline. *Alzheimers Dement (N Y)*, *7*(1), e12180. https://doi.org/10.1002/trc2.12180

Röhr, S., Pabst, A., Riedel-Heller, S. G., Jessen, F., Turana, Y., Handajani, Y. S., Brayne, C., Matthews, F. E., Stephan, B. C. M., Lipton, R. B., Katz, M. J., Wang, C., Guerchet, M., Preux, P. M., Mbelesso, P., Ritchie, K., Ancelin, M. L., Carrière, I., Guaita, A.,…Sachdev, P. S. (2020). Estimating prevalence of subjective cognitive decline in and across international cohort studies of aging: a COSMIC study. *Alzheimers Res Ther*, *12*(1), 167. https://doi.org/10.1186/s13195-020-00734-y

Rönnlund, M., Nyberg, L., Bäckman, L., & Nilsson, L. G. (2005). Stability, growth, and decline in adult life span development of declarative memory: cross-sectional and longitudinal data from a population-based study. *Psychol Aging*, *20*(1), 3–18. https://doi.org/10.1037/0882-7974.20.1.3

Rusch, H. L., Rosario, M., Levison, L. M., Olivera, A., Livingston, W. S., Wu, T., & Gill, J. M. (2019). The effect of mindfulness meditation on sleep quality: a systematic review and meta-analysis of randomized controlled trials. *Annals of the New York Academy of Sciences*, *1445*(1), 5–16. https://doi.org/https://doi.org/10.1111/nyas.13996

Rusinek, H., De Santi, S., Frid, D., Tsui, W. H., Tarshish, C. Y., Convit, A., & de Leon, M. J. (2003). Regional brain atrophy rate predicts future cognitive decline: 6-year longitudinal MR imaging study of normal aging. *Radiology*, *229*(3), 691–696. https://doi.org/10.1148/radiol.2293021299

Saha, A., Govil, D., Muhammad, T., & Thomas, A. R. (2024). Unveiling the dynamics of social engagement and subjective health in older adults: A gendered perspective. *Experimental Gerontology*, *193*, 112472. https://doi.org/https://doi.org/10.1016/j.exger.2024.112472

Salthouse, T. (2012). Consequences of Age-Related Cognitive Declines. *Annual review of psychology*, *63*(1), 201–226. https://doi.org/10.1146/annurev-psych-120710-100328

Salthouse, T. A. (2004). What and When of Cognitive Aging. *Current directions in psychological science*, *13*(4), 140–144. https://doi.org/10.1111/j.0963-7214.2004.00293.x

Salthouse, T. A. (2009). When does age-related cognitive decline begin? *Neurobiol Aging*, *30*(4), 507–514. https://doi.org/10.1016/j.neurobiolaging.2008.09.023

Salthouse, T. A. (2019). Trajectories of normal cognitive aging. *Psychol Aging*, *34*(1), 17–24. https://doi.org/10.1037/pag0000288

Samara, M. T., Huhn, M., Chiocchia, V., Schneider-Thoma, J., Wiegand, M., Salanti, G., & Leucht, S. (2020). Efficacy, acceptability, and tolerability of all available treatments for insomnia in the elderly: a systematic review and network meta-analysis. *Acta Psychiatrica Scandinavica*, *142*(1), 6–17. https://doi.org/10.1111/acps.13201

Sanchez-Lara, E., Lozano-Ruiz, A., Perez-Garcia, M., & Caracuel, A. (2022). Efficacy of mindfulness-based interventions in cognitive function in the elderly people: a systematic review and meta-analysis. *Aging & mental health*, *26*(9), 1699–1709. https://doi.org/10.1080/13607863.2021.1976724

Sapède, D., & Cau, E. (2013). The pineal gland from development to function. *Curr Top Dev Biol*, *106*, 171–215. https://doi.org/10.1016/b978-0-12-416021-7.00005-5

Sauer, S., Walach, H., Schmidt, S., Hinterberger, T., Lynch, S., Büssing, A., & Kohls, N. (2013). Assessment of Mindfulness: Review on State of the Art. *Mindfulness*, *4*(1), 3–17. https://doi.org/10.1007/s12671-012-0122-5

Schaie, K. W. (2021). Chapter 1 - History of adult cognitive aging research. In K. W. Schaie & S. L. Willis (Eds.), *Handbook of the Psychology of Aging (Ninth Edition)* (pp. 3–17). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-816094-7.00017-9

Scullin, M. K., & Bliwise, D. L. (2015). Is Cognitive Aging Associated with Levels of REM Sleep or Slow Wave Sleep? *Sleep*, *38*(3), 335–336. https://doi.org/10.5665/sleep.4482

Segal, Z., Williams, M., & Teasdale, J. (2018). *Mindfulness-based cognitive therapy for depression*. Guilford Publications.

Sevinc, G., Rusche, J., Wong, B., Datta, T., Kaufman, R., Gutz, S. E., Schneider, M., Todorova, N., Gaser, C., Thomalla, G., Rentz, D., Dickerson, B. D., & Lazar, S. W. (2021). Mindfulness Training Improves Cognition and Strengthens Intrinsic Connectivity Between the Hippocampus and Posteromedial Cortex in Healthy Older Adults. *Front Aging Neurosci*, *13*, 702796. https://doi.org/10.3389/fnagi.2021.702796

Sezer, I., Pizzagalli, D. A., & Sacchet, M. D. (2022). Resting-state fMRI functional connectivity and mindfulness in clinical and non-clinical contexts: A review and synthesis. *Neurosci Biobehav Rev*, *135*, 104583. https://doi.org/10.1016/j.neubiorev.2022.104583

Shakeel, M. K., & Goghari, V. M. (2017). Measuring Fluid Intelligence in Healthy Older Adults. *Journal of Aging Research*, *2017*, 1–6. https://doi.org/10.1155/2017/8514582

Shallcross, A. J., Visvanathan, P. D., Sperber, S. H., & Duberstein, Z. T. (2019). Waking up to the problem of sleep: can mindfulness help? A review of theory and evidence for the effects of mindfulness for sleep. *Current Opinion in Psychology*, *28*, 37–41. https://doi.org/https://doi.org/10.1016/j.copsyc.2018.10.005

Sharma, M., & Rush, S. E. (2014). Mindfulness-Based Stress Reduction as a Stress Management Intervention for Healthy Individuals. *Journal of evidence-based* *complementary & alternative medicine*, *19*(4), 271–286. https://doi.org/10.1177/2156587214543143

Sharma, N., Murari, G., Vandermorris, S., Verhoeff, N., Herrmann, N., Chen, J. J., & Mah, L. (2021). Functional Connectivity Between the Posterior Default Mode Network and Parahippocampal Gyrus Is Disrupted in Older Adults with Subjective Cognitive Decline and Correlates with Subjective Memory Ability. *J Alzheimers Dis*, *82*(1), 435–445. https://doi.org/10.3233/jad-201579

Sharma, R. A., Varga, A. W., Bubu, O. M., Pirraglia, E., Kam, K., Parekh, A., Wohlleber, M., Miller, M. D., Andrade, A., Lewis, C., Tweardy, S., Buj, M., Yau, P. L., Sadda, R., Mosconi, L., Li, Y., Butler, T., Glodzik, L., Fieremans, E.,…Osorio, R. S. (2018). Obstructive Sleep Apnea Severity Affects Amyloid Burden in Cognitively Normal Elderly. A Longitudinal Study. *American Journal of Respiratory and Critical Care Medicine*, *197*(7), 933–943. https://doi.org/10.1164/rccm.201704-0704oc

Shaurya Prakash, R., De Leon, A. A., Klatt, M., Malarkey, W., & Patterson, B. (2013). Mindfulness disposition and default-mode network connectivity in older adults. *Social Cognitive and Affective Neuroscience*, *8*(1), 112–117. https://doi.org/10.1093/scan/nss115

Si, T., Xing, G., & Han, Y. (2020). Subjective Cognitive Decline and Related Cognitive Deficits. *Frontiers in Neurology*, *11*. https://doi.org/10.3389/fneur.2020.00247

Siddarth, P., Thana-Udom, K., Ojha, R., Merrill, D., Dzierzewski, J. M., Miller, K., Small, G. W., & Ercoli, L. (2021). Sleep quality, neurocognitive performance, and memory self-appraisal in middle-aged and older adults with memory complaints. *International Psychogeriatrics*, *33*(7), 703–713. https://doi.org/10.1017/s1041610220003324

Silvia, P. J., & Sanders, C. E. (2010). Why are smart people curious? Fluid intelligence, openness to experience, and interest. *Learning and Individual Differences*, *20*(3), 242–245. https://doi.org/10.1016/j.lindif.2010.01.006

Singh-Manoux, A., Kivimaki, M., Glymour, M. M., Elbaz, A., Berr, C., Ebmeier, K. P., Ferrie, J. E., & Dugravot, A. (2012). Timing of onset of cognitive decline: results from Whitehall II prospective cohort study. *Bmj*, *344*, d7622. https://doi.org/10.1136/bmj.d7622

Slot, R. E. R., Sikkes, S. A. M., Berkhof, J., Brodaty, H., Buckley, R., Cavedo, E., Dardiotis, E., Guillo-Benarous, F., Hampel, H., Kochan, N. A., Lista, S., Luck, T., Maruff, P., Molinuevo, J. L., Kornhuber, J., Reisberg, B., Riedel-Heller, S. G., Risacher, S. L., Roehr, S.,…Flier, W. M. (2019). Subjective cognitive decline and rates of incident Alzheimer's disease and non–Alzheimer's disease dementia. *Alzheimer's & Dementia*, *15*(3), 465–476. https://doi.org/10.1016/j.jalz.2018.10.003

Smart, C. M., Segalowitz, S. J., Mulligan, B. P., Koudys, J., & Gawryluk, J. R. (2016). Mindfulness Training for Older Adults with Subjective Cognitive Decline: Results from a Pilot Randomized Controlled Trial. *Journal of Alzheimer's Disease*, *52*, 757–774. https://doi.org/10.3233/JAD-150992

Solano Lopez, A. L. (2018). Effectiveness of the mindfulness-based stress reduction program on blood pressure: A systematic review of literature. *Worldviews on Evidence-Based Nursing*, *15*(5), 344–352.

Sommerlad, A., Kivimäki, M., Larson, E. B., Röhr, S., Shirai, K., Singh-Manoux, A., & Livingston, G. (2023). Social participation and risk of developing dementia. *Nature Aging*, *3*(5), 532–545. https://doi.org/10.1038/s43587-023-00387-0

Sorella, S., Crescentini, C., Matiz, A., Chang, M., & Grecucci, A. (2025). Resting-state BOLD temporal variability of the default mode network predicts spontaneous mind wandering, which is negatively associated with mindfulness skills. *Front Hum Neurosci*, *19*, 1515902. https://doi.org/10.3389/fnhum.2025.1515902

Spira, A. P., Chen-Edinboro, L. P., Wu, M. N., & Yaffe, K. (2014). Impact of sleep on the risk of cognitive decline and dementia. *Current Opinion in Psychiatry*, *27*(6), 478–483. https://doi.org/10.1097/yco.0000000000000106

Spooner, D. M., & Pachana, N. A. (2006). Ecological validity in neuropsychological assessment: a case for greater consideration in research with neurologically intact populations. *Arch Clin Neuropsychol*, *21*(4), 327–337. https://doi.org/10.1016/j.acn.2006.04.004

Steriade, M., & Llinás, R. R. (1988). The functional states of the thalamus and the associated neuronal interplay. *Physiol Rev*, *68*(3), 649–742. https://doi.org/10.1152/physrev.1988.68.3.649

Stern, Y., Arenaza-Urquijo, E. M., Bartrés-Faz, D., Belleville, S., Cantilon, M., Chetelat, G., Ewers, M., Franzmeier, N., Kempermann, G., Kremen, W. S., Okonkwo, O., Scarmeas, N., Soldan, A., Udeh-Momoh, C., Valenzuela, M., Vemuri, P., & Vuoksimaa, E. (2020). Whitepaper: Defining and investigating cognitive reserve, brain reserve, and brain maintenance. *Alzheimer's & Dementia*, *16*(9), 1305–1311. https://doi.org/10.1016/j.jalz.2018.07.219

Stewart, R. (2012). Subjective cognitive impairment. *Current Opinion in Psychiatry*, *25*(6), 445–450. https://doi.org/10.1097/YCO.0b013e3283586fd8

Strauss, C., Cavanagh, K., Oliver, A., & Pettman, D. (2014). Mindfulness-based interventions for people diagnosed with a current episode of an anxiety or depressive disorder: a meta-analysis of randomised controlled trials. *PLoS One*, *9*(4), e96110. https://doi.org/10.1371/journal.pone.0096110

Streeter, C. C., Whitfield, T. H., Owen, L., Rein, T., Karri, S. K., Yakhkind, A., Perlmutter, R., Prescot, A., Renshaw, P. F., Ciraulo, D. A., & Jensen, J. E. (2010). Effects of Yoga Versus Walking on Mood, Anxiety, and Brain GABA Levels: A Randomized Controlled MRS Study. *The Journal of Alternative and Complementary Medicine*, *16*(11), 1145–1152. https://doi.org/10.1089/acm.2010.0007

Strikwerda-Brown, C., Ozlen, H., Binette, A. P., Chapleau, M., Marchant, N. L., Breitner, J. C. S., Villeneuve, S., & Group, f. t. P.-A. R. (2021). Trait mindfulness is associated with less amyloid, tau, and cognitive decline in individuals at risk for Alzheimer's disease. *medRxiv*, 2021.2005.2017.21257320. https://doi.org/10.1101/2021.05.17.21257320

Sun, M., Zhang, Q., Han, Y., & Liu, J. (2024). Sleep Quality and Subjective Cognitive Decline among Older Adults: The Mediating Role of Anxiety/Depression and Worries. *Journal of Aging Research*, *2024*, 1–10. https://doi.org/10.1155/2024/4946303

Tang, R., & Braver, T. S. (2020). Towards an Individual Differences Perspective in Mindfulness Training Research: Theoretical and Empirical Considerations [Review]. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.00818

Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213–225. https://doi.org/10.1038/nrn3916

Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2016). Traits and states in mindfulness meditation. *Nature Reviews Neuroscience*, *17*(1), 59–59. https://doi.org/10.1038/nrn.2015.7

Tang, Y.-Y., Tang, R., Rothbart, M. K., & Posner, M. I. (2019). Frontal theta activity and white matter plasticity following mindfulness meditation. *Current Opinion in Psychology*, *28*, 294–297.

Team, R. C. (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. *http://www. R-project. org/.*

Teasdale, J. D., Segal, Z. V., Williams, J. M. G., Ridgeway, V. A., Soulsby, J. M., & Lau, M. A. (2000). Prevention of relapse/recurrence in major depression by mindfulness-based cognitive therapy. *Journal of Consulting and Clinical Psychology*, *68*(4), 615.

Toda, T., & Gage, F. H. (2018). Review: adult neurogenesis contributes to hippocampal plasticity. *Cell Tissue Res*, *373*(3), 693–709. https://doi.org/10.1007/s00441-017-2735-4

Tokoro, K., Sato, H., Yamamoto, M., & Nagai, Y. (2015). [Thalamus and Attention]. *Brain Nerve*, *67*(12), 1471–1480. https://doi.org/10.11477/mf.1416200324

Tooley, G. A., Armstrong, S. M., Norman, T. R., & Sali, A. (2000). Acute increases in night-time plasma melatonin levels following a period of meditation. *Biol Psychol*, *53*(1), 69–78. https://doi.org/10.1016/s0301-0511(00)00035-1

Torrico, T. J., & Munakomi, S. (2025). Neuroanatomy, Thalamus. In *StatPearls*. StatPearls Publishing

Copyright © 2025, StatPearls Publishing LLC.

Toussaint, P.-J., Maiz, S., Coynel, D., Doyon, J., Messé, A., de Souza, L. C., Sarazin, M., Perlbarg, V., Habert, M.-O., & Benali, H. (2014). Characteristics of the default mode functional connectivity in normal ageing and Alzheimer's disease using resting state fMRI with a combined approach of entropy-based and graph theoretical measurements. *NeuroImage*, *101*, 778–786.

Tsapanou, A., Vlachos, G. S., Cosentino, S., Gu, Y., Manly, J. J., Brickman, A. M., Schupf, N., Zimmerman, M. E., Yannakoulia, M., Kosmidis, M. H., Dardiotis, E., Hadjigeorgiou, G., Sakka, P., Stern, Y., Scarmeas, N., & Mayeux, R. (2019). Sleep and subjective cognitive decline in cognitively healthy elderly: Results from two cohorts. *Journal of Sleep Research*, *28*(5). https://doi.org/10.1111/jsr.12759

Tucker-Drob, E. M. (2019). Cognitive Aging and Dementia: A Life-Span Perspective. *Annual Review of Developmental Psychology*, *1*(1), 177–196. https://doi.org/10.1146/annurev-devpsych-121318-085204

Ulrich, D. (2016). Sleep spindles as facilitators of memory formation and learning. *Neural Plasticity*, *2016*.

Vago, D. R., & Silbersweig, D. A. (2012). Self-awareness, self-regulation, and self-transcendence (S-ART): a framework for understanding the neurobiological mechanisms of mindfulness. *Frontiers in Human Neuroscience*, *6*, 296.

Valenzuela, M. J., Sachdev, P., Wen, W., Chen, X., & Brodaty, H. (2008). Lifespan mental activity predicts diminished rate of hippocampal atrophy. *PLoS One*, *3*(7), e2598.

Vallesi, A., Tronelli, V., Lomi, F., & Pezzetta, R. (2021). Age differences in sustained attention tasks: A meta-analysis. *Psychonomic Bulletin & Review, 28*(6), 1755–1775. https://doi.org/10.3758/s13423-021-01908-x

Van de Mortel, T. (2008). Faking it: Social desirability response bias in self-report research. *Thea van de Mortel*, *25*.

van Harten, A. C., Mielke, M. M., Swenson-Dravis, D. M., Hagen, C. E., Edwards, K. K., Roberts, R. O., Geda, Y. E., Knopman, D. S., & Petersen, R. C. (2018). Subjective cognitive decline and risk of MCI: The Mayo Clinic Study of Aging. *Neurology*, *91*(4), e300–e312. https://doi.org/10.1212/wnl.0000000000005863

van Leeuwen, S., Müller, N. G., & Melloni, L. (2009). Age effects on attentional blink performance in meditation. *Consciousness and Cognition*, *18*(3), 593–599.

Verfaillie, S. C. J., Timmers, T., Slot, R. E. R., Van Der Weijden, C. W. J., Wesselman, L. M. P., Prins, N. D., Sikkes, S. A. M., Yaqub, M., Dols, A., Lammertsma, A. A., Scheltens, P., Ossenkoppele, R., Van Berckel, B. N. M., & Van Der Flier, W. M. (2019). Amyloid-β Load Is Related to Worries, but Not to Severity of Cognitive Complaints in Individuals With Subjective Cognitive Decline: The SCIENCe Project. *Frontiers in Aging Neuroscience*, *11*. https://doi.org/10.3389/fnagi.2019.00007

Wahbeh, H. (2018). Internet Mindfulness Meditation Intervention (IMMI) Improves Depression Symptoms in Older Adults. *Medicines (Basel)*, *5*(4). https://doi.org/10.3390/medicines5040119

Wallin, A., Nordlund, A., Jonsson, M., Lind, K., Edman, Å., Göthlin, M., Stålhammar, J., Eckerström, M., Kern, S., Börjesson-Hanson, A., Carlsson, M., Olsson, E., Zetterberg, H., Blennow, K., Svensson, J., Öhrfelt, A., Bjerke, M., Rolstad, S., & Eckerström, C. (2016). The Gothenburg MCI study: Design and distribution of Alzheimer's disease and subcortical vascular disease diagnoses from baseline to 6-year follow-up. *Journal of Cerebral Blood Flow & Metabolism*, *36*(1), 114–131. https://doi.org/10.1038/jcbfm.2015.147

Wang, L., LaViolette, P., O'Keefe, K., Putcha, D., Bakkour, A., Van Dijk, K. R. A., Pihlajamäki, M., Dickerson, B. C., & Sperling, R. A. (2010). Intrinsic connectivity between the hippocampus and posteromedial cortex predicts memory performance in cognitively intact older individuals. *NeuroImage*, *51*(2), 910–917. https://doi.org/https://doi.org/10.1016/j.neuroimage.2010.02.046

Wang, X., Huang, W., Su, L., Xing, Y., Jessen, F., Sun, Y., Shu, N., & Han, Y. (2020). Neuroimaging advances regarding subjective cognitive decline in preclinical Alzheimer's disease. *Molecular Neurodegeneration*, *15*(1). https://doi.org/10.1186/s13024-020-00395-3

Wang, X., Li, P., Pan, C., Dai, L., Wu, Y., & Deng, Y. (2019). The Effect of Mind-Body Therapies on Insomnia: A Systematic Review and Meta-Analysis. *Evidence-Based Complementary and Alternative Medicine*, *2019*, 9359807. https://doi.org/10.1155/2019/9359807

Wang, Y., Risacher, S. L., West, J. D., McDonald, B. C., Magee, T. R., Farlow, M. R., Gao, S., O'Neill, D. P., & Saykin, A. J. (2013). Altered default mode network connectivity in older adults with cognitive complaints and amnestic mild cognitive impairment. *J Alzheimers Dis*, *35*(4), 751–760. https://doi.org/10.3233/jad-130080

Wang, Y. Y., Wang, F., Zheng, W., Zhang, L., Ng, C. H., Ungvari, G. S., & Xiang, Y. T. (2020). Mindfulness-Based Interventions for Insomnia: A Meta-Analysis of Randomized Controlled Trials. *Behavioral sleep medicine*, *18*(1), 1–9. https://doi.org/10.1080/15402002.2018.1518228

Weber, M., Schnorr, T., Morat, M., Morat, T., & Donath, L. (2020). Effects of Mind–Body Interventions Involving Meditative Movements on Quality of Life, Depressive Symptoms, Fear of Falling and Sleep Quality in Older Adults: A Systematic Review with Meta-Analysis. *International Journal of Environmental Research and Public Health*, *17*(18), 6556. https://doi.org/10.3390/ijerph17186556

Wecker, N. S., Kramer, J. H., Wisniewski, A., Delis, D. C., & Kaplan, E. (2000). Age effects on executive ability. *Neuropsychology*, *14*(3), 409–414. https://doi.org/10.1037//0894-4105.14.3.409

Wells, R. E., Kerr, C., Dossett, M. L., Danhauer, S. C., Sohl, S. J., Sachs, B. C., Feeley, J. W., Wolkin, J., Wall, R., Kaptchuk, T., Press, D. Z., Phillips, R. S., & Yeh, G. Y. (2019). Can Adults with Mild Cognitive Impairment Build Cognitive Reserve and Learn Mindfulness Meditation? Qualitative Theme Analyses from a Small Pilot Study. *Journal of Alzheimers Disease*, *70*(3), 825–842. https://doi.org/10.3233/jad-190191

Wells, R. E., Yeh, G. Y., Kerr, C. E., Wolkin, J., Davis, R. B., Tan, Y., Spaeth, R., Wall, R. B., Walsh, J., Kaptchuk, T. J., Press, D., Phillips, R. S., & Kong, J. (2013). Meditation's impact on default mode network and hippocampus in mild cognitive impairment: A pilot study. *Neuroscience Letters*, *556*, 15–19. https://doi.org/10.1016/j.neulet.2013.10.001

Wesbecher, K. (2018). *Dispositional mindfulness and positive psychological processes in older adults: Executive functioning, positive reappraisal and meaning in life* ProQuest Information & Learning]. APA PsycInfo. https://login.jproxy.nuim.ie/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2018-48576-160&site=ehost-live

West, R. (2004). The effects of aging on controlled attention and conflict processing in the Stroop task. *J Cogn Neurosci*, *16*(1), 103–113. https://doi.org/10.1162/089892904322755593

Westbrook, C., Creswell, J. D., Tabibnia, G., Julson, E., Kober, H., & Tindle, H. A. (2013). Mindful attention reduces neural and self-reported cue-induced craving in smokers. *Soc Cogn Affect Neurosci*, *8*(1), 73–84. https://doi.org/10.1093/scan/nsr076

Westerberg, C. E., Mander, B. A., Florczak, S. M., Weintraub, S., Mesulam, M.-M., Zee, P. C., & Paller, K. A. (2012). Concurrent impairments in sleep and memory in amnestic mild cognitive impairment. *Journal of the International Neuropsychological Society*, *18*(3), 490–500.

Wetherell, J. L., Hershey, T., Hickman, S., Tate, S. R., Dixon, D., Bower, E. S., & Lenze, E. J. (2017). Mindfulness-Based Stress Reduction for Older Adults With Stress Disorders and Neurocognitive Difficulties. *The Journal of Clinical Psychiatry*, *78*(7), e734–e743. https://doi.org/10.4088/jcp.16m10947

Wheeler, M. S., Arnkoff, D. B., & Glass, C. R. (2016). What is being studied as mindfulness meditation? *Nature Reviews Neuroscience*, *17*(1), 59–59. https://doi.org/10.1038/nrn.2015.6

Whitfield, T., Barnhofer, T., Acabchuk, R., Cohen, A., Lee, M., Schlosser, M., Arenaza-Urquijo, E. M., Böttcher, A., Britton, W., Coll-Padros, N., Collette, F., Chételat, G., Dautricourt, H., Dumais, T., Klimecki, O., Meiberth, D., Moulinet, I., Müller, T., Parsons, E.,…Marchant, N. L. (2022). The Effect of Mindfulness-based Programs on Cognitive Function in Adults: A Systematic Review and Meta-analysis. *Neuropsychology Review*, *32*(3), 677–702. https://doi.org/10.1007/s11065-021-09519-y

Whitfield, T., Demnitz-King, H., Schlosser, M., Barnhofer, T., Frison, E., Coll-Padros, N., Dautricourt, S., Requier, F., Delarue, M., Gonneaud, J., Klimecki, O. M., Lutz, A., Paly, L., Salmon, E., Schild, A.-K., Walker, Z., Jessen, F., Chételat, G., Collette, F.,…Wingrove, J. (2022). Effects of a mindfulness-based versus a health self-management intervention on objective cognitive performance in older adults with subjective cognitive decline (SCD): a secondary analysis of the SCD-Well randomized controlled trial. *Alzheimer's Research & Therapy*, *14*(1). https://doi.org/10.1186/s13195-022-01057-w

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.-W., Da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R.,…Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, *3*(1), 160018. https://doi.org/10.1038/sdata.2016.18

Williams, J. M. G., Crane, C., Barnhofer, T., Brennan, K., Duggan, D. S., Fennell, M. J., Hackmann, A., Krusche, A., Muse, K., & Von Rohr, I. R. (2014). Mindfulness-based cognitive therapy for preventing relapse in recurrent depression: a randomized dismantling trial. *Journal of Consulting and Clinical Psychology*, *82*(2), 275.

Wolfsgruber, S., Polcher, A., Koppara, A., Kleineidam, L., Frölich, L., Peters, O., Hüll, M., Rüther, E., Wiltfang, J., Maier, W., Kornhuber, J., Lewczuk, P., Jessen, F., Wagner, M., & Tales, A. (2017). Cerebrospinal Fluid Biomarkers and Clinical Progression in Patients with Subjective Cognitive Decline and Mild Cognitive Impairment. *Journal of Alzheimer's Disease*, *58*(3), 939–950. https://doi.org/10.3233/jad-161252

World Health Organization. (2015). *World Report on Ageing and Health Summary*. World Health Organization.

World Health Organization. (2020). *Decade of healthy ageing: baseline report*. World Health Organization.

Xie, L., Kang, H., Xu, Q., Chen, M. J., Liao, Y., Thiyagarajan, M., O'Donnell, J., Christensen, D. J., Nicholson, C., & Iliff, J. J. (2013). Sleep drives metabolite clearance from the adult brain. *science*, *342*(6156), 373–377.

Xiong, G. L., & Doraiswamy, P. M. (2009). Does Meditation Enhance Cognition and Brain Plasticity? *Annals of the New York Academy of Sciences*, *1172*(1), 63–69. https://doi.org/https://doi.org/10.1196/annals.1393.002

Xu, J. (2018). A Tripartite Function of Mindfulness in Adjustment to Aging: Acceptance, Integration, and Transcendence. *Gerontologist*, *58*(6), 1009–1015. https://doi.org/10.1093/geront/gnx100

Xu, W., Tan, C.-C., Zou, J.-J., Cao, X.-P., & Tan, L. (2020). Sleep problems and risk of all-cause cognitive decline or dementia: an updated systematic review and meta-analysis. *Journal of Neurology, Neurosurgery &amp;amp; Psychiatry*, *91*(3), 236. https://doi.org/10.1136/jnnp-2019-321896

Xu, X., Yuan, H., & Lei, X. (2016). Activation and Connectivity within the Default Mode Network Contribute Independently to Future-Oriented Thought. *Scientific Reports*, *6*(1), 21001. https://doi.org/10.1038/srep21001

Yaggi, H. K., Araujo, A. B., & McKinlay, J. B. (2006). Sleep duration as a risk factor for the development of type 2 diabetes. *Diabetes care*, *29*(3), 657–661.

Yegorov, Y. E., Poznyak, A. V., Nikiforov, N. G., Sobenin, I. A., & Orekhov, A. N. (2020). The Link between Chronic Stress and Accelerated Aging. *Biomedicines*, *8*(7), 198. https://doi.org/10.3390/biomedicines8070198

Yeshurun, Y., Nguyen, M., & Hasson, U. (2021). The default mode network: where the idiosyncratic self meets the shared social world. *Nat Rev Neurosci*, *22*(3), 181–192. https://doi.org/10.1038/s41583-020-00420-w

Yingmei, H., Chaojie, W., Yi, Z., Yijie, L., Heng, Z., Ze, F., Weiqing, L., Bingyuan, C., & Feng, W. (2025). Research progress on brain network imaging biomarkers of subjective cognitive decline. *Frontiers in Neuroscience*, *19*. https://doi.org/10.3389/fnins.2025.1503955

Yochim, B. P., & Mast, B. T. (2021). Chapter 15 - Psychological assessment of neurocognitive disorders. In K. W. Schaie & S. L. Willis (Eds.), *Handbook of the Psychology of Aging (Ninth Edition)* (pp. 251–262). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-816094-7.00006-4

Youngstedt, S. D. (2003). Ceiling and floor effects in sleep research. *Sleep medicine reviews*, *7*(4), 351–365. https://doi.org/https://doi.org/10.1053/smrv.2001.0239

Yue, W. L., Ng, K. K., Koh, A. J., Perini, F., Doshi, K., Zhou, J. H., & Lim, J. (2023). Mindfulness-based therapy improves brain functional network reconfiguration efficiency. *Translational Psychiatry*, *13*(1). https://doi.org/10.1038/s41398-023-02642-9

Zainal, N. H., & Newman, M. G. (2024). Mindfulness enhances cognitive functioning: a meta-analysis of 111 randomized controlled trials. *Health Psychol Rev*, *18*(2), 369–395. https://doi.org/10.1080/17437199.2023.2248222

Zec, R. F., Markwell, S. J., Burkett, N. R., & Larsen, D. L. (2005). A longitudinal study of confrontation naming in the "normal" elderly. *J Int Neuropsychol Soc*, *11*(6), 716–726. https://doi.org/10.1017/s1355617705050897

Zellner Keller, B., Singh, N. N., & Winton, A. S. W. (2014). Mindfulness-Based Cognitive Approach for Seniors (MBCAS): Program Development and Implementation. *Mindfulness*, *5*(4), 453–459. https://doi.org/10.1007/s12671-013-0262-2

Zhang, J.-X., Liu, X.-H., Xie, X.-H., Zhao, D., Shan, M.-S., Zhang, X.-L., Kong, X.-M., & Cui, H. (2015). Mindfulness-Based Stress Reduction for Chronic Insomnia in Adults Older than 75 Years: A Randomized, Controlled, Single-Blind Clinical Trial. *EXPLORE*, *11*(3), 180–185. https://doi.org/10.1016/j.explore.2015.02.005

Zimmerman, M. E., Bigal, M. E., Katz, M. J., Brickman, A. M., & Lipton, R. B. (2012). Sleep Onset/Maintenance Difficulties and Cognitive Function in Nondemented Older Adults: The Role of Cognitive Reserve. *Journal of the International Neuropsychological Society*, *18*(03), 461–470. https://doi.org/10.1017/s1355617711001901

Zimmerman, M. E., & Brickman, A. M. (2009). Neuropsychology of healthy aging. In *HIV and the Brain* (pp. 347–367). Springer.

Zimprich, D., Allemand, M., & Dellenbach, M. (2009). Openness to Experience, fluid intelligence, and crystallized intelligence in middle-aged and old adults. *Journal of Research in Personality*, *43*(3), 444–454. https://doi.org/10.1016/j.jrp.2009.01.018

Zlatar, Z. Z., Moore, R. C., Palmer, B. W., Thompson, W. K., & Jeste, D. V. (2014). Cognitive complaints correlate with depression rather than concurrent objective cognitive impairment in the successful aging evaluation baseline sample. *J Geriatr Psychiatry Neurol*, *27*(3), 181–187. https://doi.org/10.1177/0891988714524628

Zlatar, Z. Z., Muniz, M., Galasko, D., & Salmon, D. P. (2018). Subjective Cognitive Decline Correlates With Depression Symptoms and Not With Concurrent Objective Cognition in a Clinic-Based Sample of Older Adults. *J Gerontol B Psychol Sci Soc Sci*, *73*(7), 1198–1202. https://doi.org/10.1093/geronb/gbw207

Zullo, L., Clark, C., Gholam, M., Castelao, E., von Gunten, A., Preisig, M., & Popp, J. (2021). Factors associated with subjective cognitive decline in dementia-free older adults—A population-based study. *International Journal of Geriatric Psychiatry*, *36*(8), 1188–1196. https://doi.org/https://doi.org/10.1002/gps.5509

# Appendices

## Chapter 2 Appendix

## Appendix A – Search Strategy

**Search Terms: (Filter: 10 years)**
Keywords (intervention/exposure): “mindfulness-based intervention” OR “MBI” OR “MBSR” OR “MBCT” OR “mindfulness” OR “mindfulness-based stress reduction” OR “mindfulness-based cognitive therapy” OR “meditation”,
AND (population of interest): “healthy elderly” OR “elderly” OR “older adults” OR “old adults” OR “ageing” OR “cognitive ageing” OR “cognitively healthy older adults”.
AND/OR (cognitive function): “cognition”, “cognitive function”, “cognitive performance”, “cognitive abilities”.
AND/OR (sleep quality): “sleep”, “sleep quality”.

**Other Sources**
Reference lists of review articles, included studies, authors’ own files and Google scholar.

## Appendix B – Excluded Studies Table

**Participants:** include studies where authors have reported the sample as older adults, and mean age exceeds 60. However, if the age range goes below 55 the study should be excluded. Exclude studies where the participants have a clinical diagnosis of mild cognitive impairment or worse. Exclude studies if participants have clinical diagnosis of depression/anxiety/mental illness.

**Intervention:** The intervention should be based on MBSR/MBCT, or use similar mindfulness practices. Studies that implement interventions that do not teach any form of yoga/mindful movement and are shorter than 6 weeks should be excluded. Group sizes should be min. 10. Must have control group.

| Excluded Text | Reason for Exclusion |
|---|---|
| Brisbon 2017 | Age range 34+ |
| Fountain-Zaragoza 2016 | Cross sectional – unsure where RCT data is taken from |
| Fiocco 2015 | Cross sectional |
| Gard 2014 | Average age <60 |
| Gross 2011 | Age 18-65 |
| Haddad 2019 | Secondary analysis of Wetherell (2017), duplicate data |
| Huang 2019 | Pre-post and no neuropsychological tests |
| Wahbeh (2016) | Feasibility study, pre-post, <10 participants in each group |
| Klee (2020) | Some self-report questionnaires were taken by participants but not recorded here (PSQI was one of them). However, age range was 50-85, despite average age being 60. |
| Mallya 2019 | Participants are carers aged 50+ |
| Foulk 2014 | Exploratory pre-post design; no control |
| Lenze 2014 | Cognitive dysfunction |
| Moynihan 2010 | Abstract a duplicate of 2013 included study |
| Prakash 2013 | Correlational |
| Visser 2014 | Cross-sectional secondary analysis of Moynihan (2013) data |
| Tam 2017 | Intervention not based in MBSR, only 2 weeks long |
| Sun 2013 | Intervention not appropriate, not based on MBSR |
| Wetherell 2017 | Participants had clinical levels of anxiety or depression. |
| Wetherell 2020 | Pilot data from 1 of the intervention groups of the RCT (non-randomised) |
| Isbel (2019) | MBI differs too much from MBSR – missing key component of mindful movement/hatha yoga. Focus is on EEG data. |
| Isbel (2020) | MBI differs too much from MBSR – missing key component of mindful movement/hatha yoga. Focus is on EEG data. |
| Malinowski (2017) | No yoga/mindful movement in MBI and participants were asked to practice mindfulness min. 10 minutes per day, 5 days a week, less than asked in MBSR, and group sessions were not weekly. Cognitive status of participants unclear. |

| | |
|---|---|
| Zhang (2015) | Exclusion for cognitive status was dementia, so individuals with MCI could have been included. Didn’t use any yoga. |
| Gothe (2016) | Only used hatha yoga and no other form of mindfulness practice, so deviates too much from MBSR/MBCT |

# Appendix C – Included Studies Table

**Table**

Characteristics of studies included in the systematic review

| Author (year) Country | Intervention/ control | Methods | Participants | % Female | Outcomes of interest | Notes |
|---|---|---|---|---|---|---|
| Black et al. (2015) California, USA | Mindfulness Awareness Practices vs. Sleep Education Hygiene | Single-site, parallel-group RCT<br>Weekly 2 hour mindfulness sessions for 6 weeks. Daily home practice.<br>Inclusion required >23 MMSE score and no current meditation practice | EG: 24<br>CG: 25<br>Age: >55, M=66.3. SD=7.4 | 67% | Sleep Quality (PSQI)[a] | Mindfulness group also showed significant improvement relative to sleep education group on secondary health outcomes of insomnia symptoms, depression symptoms, fatigue interference, and fatigue severity. |
| Gallegos et al. (2016) New York, USA | MBSR vs. Waitlist control | Secondary analysis from RCT of MBSR Program (Moynihan, 2013)<br>Weekly 2 hour mindfulness sessions for 8 weeks. Daily home practice. One "all-day" 7 hour retreat.<br>Inclusion required >24 MMSE score | EG: 100<br>CG: 100<br>Age: >63, M=72.5 SD=6.7 | 62% | Sleep Quality (PSQI)[a] | Among participants with baseline PSQI score > 5, mean PSQI score decreased 2.2 points from baseline to post-treatment for the MBSR group and .58 points for control group.<br>Among participants with baseline ≥ 10 PSQI, mean PSQI score decreased 3.9 points from baseline to follow-up for the MBSR group and .6 points in the control group. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mallya & Fiocco (2016) Toronto, Canada | MBSR (altered) vs. Reading & Relaxation | RCT<br>Weekly 2.5 hour mindfulness sessions for 8 weeks and daily home practice. No retreat.<br>Excluded if any medical/psychiatric conditions that might significantly affect cognitive performance, such as a neurodegenerative disorder, recently diagnosed psychopathology, stroke, or diabetes. | EG: 57<br>CG: 40<br>Age: >60, M=69.26, SD=4.75 | 74% | Overall Cog. Function (MMSE)[c]<br>Executive Function (Trail Making Tests A+B)[c]<br>Verbal Fluency (Controlled Oral Word Association Task)[c]<br>Verbal Memory (California Verbal Learning Test-Long Delay Free Recall)[c] | |
| Moynihan (2013) Virginia, USA | MBSR vs. Waitlist Control | RCT<br>Weekly 2 hour mindfulness sessions for 8 weeks. Daily home practice. One "all-day" 7 hour retreat.<br>Inclusion required >24 MMSE score | EG: 100<br>CG: 101<br>Age: >63, M=73.45, SD= 6.7 | 62% | Executive Function (Trail Making Test B/A ratio)[a] | Also found significant rightward frontal alpha activation after MBI. |
| Smart et al. (2016) British Columbia, Canada | Mindfulness Training vs. Psychoeducation, groups split further between SCD and healthy controls | Single-blind RCT<br>Weekly 2 hour mindfulness sessions for 8 weeks. Daily home practice. Based on MBSR.<br>Inclusion required >25 MMSE score | EG: 19<br>CG: 17<br>Age: 65-80, M=69.8, SD=3.52 | 53% | Cognitive Complaints Index (composite measure of selected items from Geriatric Depression Scale, Memory Complaints Questionnaire, and Metamemory in Adulthood Questionnaire) [c]<br>Attention stability (Reaction time on go/nogo task) [a] | Found robust changes in percent brain volume change between mindfulness training and psychoeducation |

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| Bubb (2014) Pennsylvania, USA | MBSR (altered) vs. Waitlist control and Mind Aerobics | RCT<br>Weekly 2.5 hour mindfulness sessions for 8 weeks and daily home practice. Unclear whether there was a retreat.<br>Inclusion required >26 MMSE score | MBSR group: 15<br>MBSR waitlist: 17<br>Mind Aerobics group: 22<br>Mind Aerobics waitlist: 16<br>Age: >60, M=82.37 SD=6.71 | 84% | Executive Function/Attention (Trail Making Test, Stroop, ANT)$^{c}$<br>General Cognition Composite$^{c}$<br>Working Memory (WAIS-IV)$^{c}$<br>Verbal Composite$^{c}$<br>Processing Speed (Cancellation Time Composite)$^{c}$ |  |
| Sevinc et al. (2021) Massachusetts, USA | Mindfulness Training vs Cognitive fitness control | RCT<br>Weekly meetings lasted 1 h: 45 min meditation practice and 15 min of check-in, practice instruction, and Q&A. 45 mins daily home practice with guided audio. No retreat.<br>Inclusion required >27 MMSE | MBSR group: 72<br>Cognitive fitness training: 74<br>Age: 65-80, M=70.6 SD=4.2 | 54.5% | Preclinical Alzheimer Cognitive Composite (PACC) $^{b}$<br>Free Recall (Free and Cued Selective Reminding Test) $^{b}$<br>Delayed Recall (Logical Memory IIa subtest from the Wechsler Memory Scale) $^{b}$<br>Executive Function (Digit Symbol Substitution Test from the Wechsler Adult Intelligence Scale) $^{c}$<br>Global cognition (MMSE) $^{c}$<br>Sleep quality (PSQI) $^{c}$ | Greater improvement in the MBI group on the PACC was associated with a larger unique increase in intrinsic connectivity between the right hippocampus and posteromedial cortex and between the left hippocampus and lateral parietal cortex. |

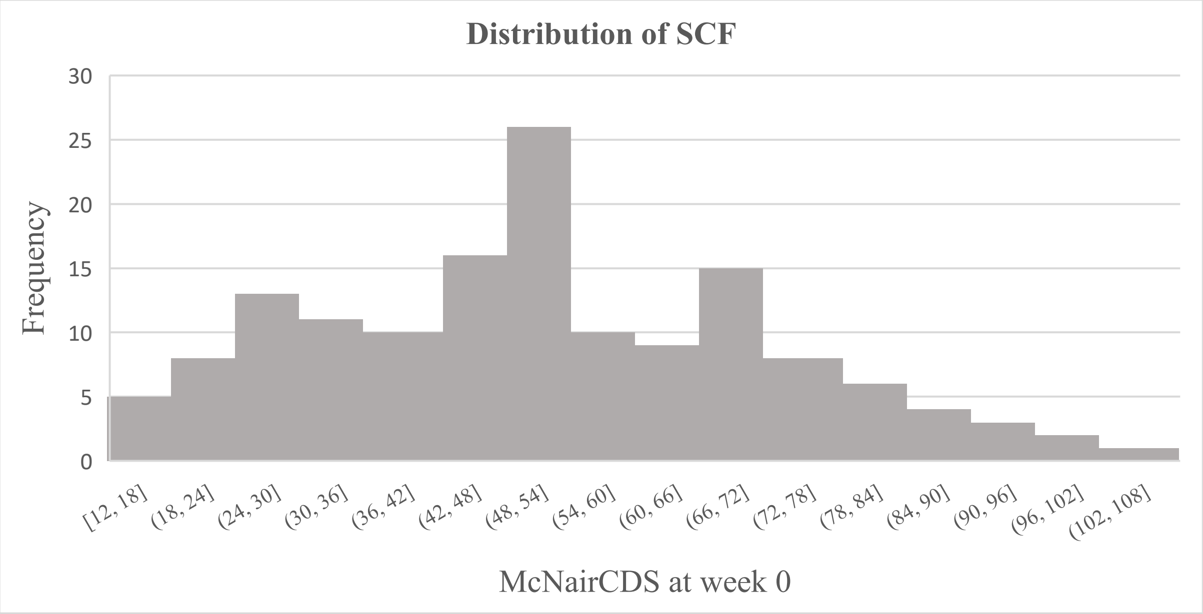
Key: EG=experimental group, CG=control group, RCT=randomized controlled trial, MBSR=mindfulness-based stress reduction, FFMQ=five facet mindfulness questionnaire, MAAS=mindfulness attention awareness scale, MMSE=mini-mental state exam, M=mean, SD=standard deviation, a=Significantly greater improvement for training versus control, b=Significant training effects for experimental group from BL to PT; no significant effect for controls, c=No significant intervention difference between experimental and control groups.

## Chapter 3 Appendix

## Appendix D

**Figure**

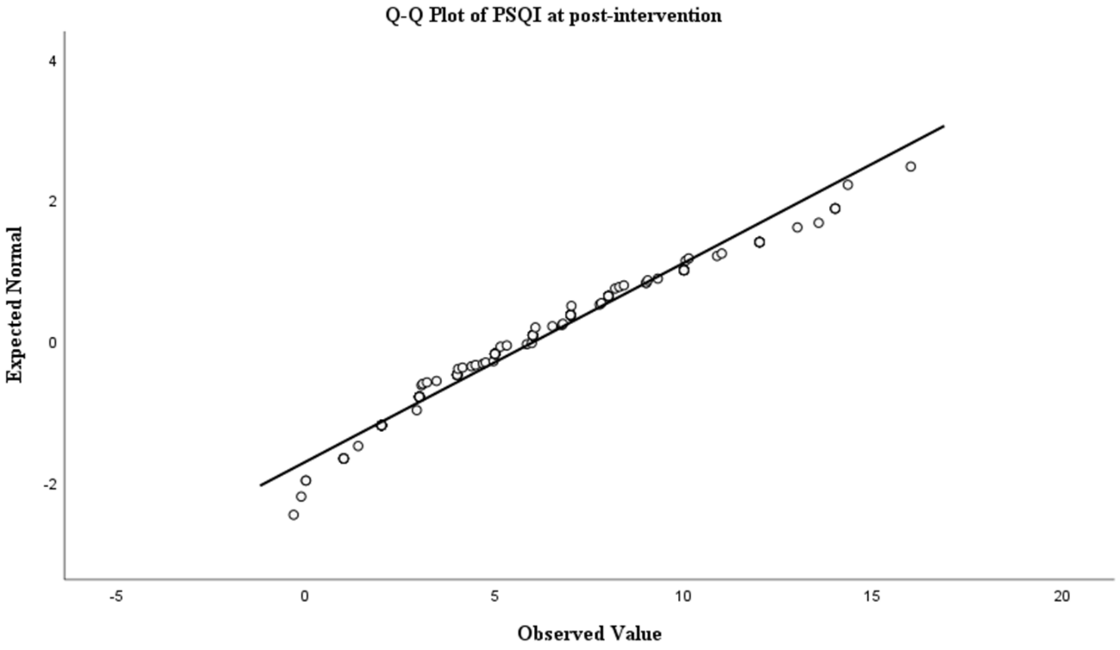
*Histogram of CDS scores at Baseline*

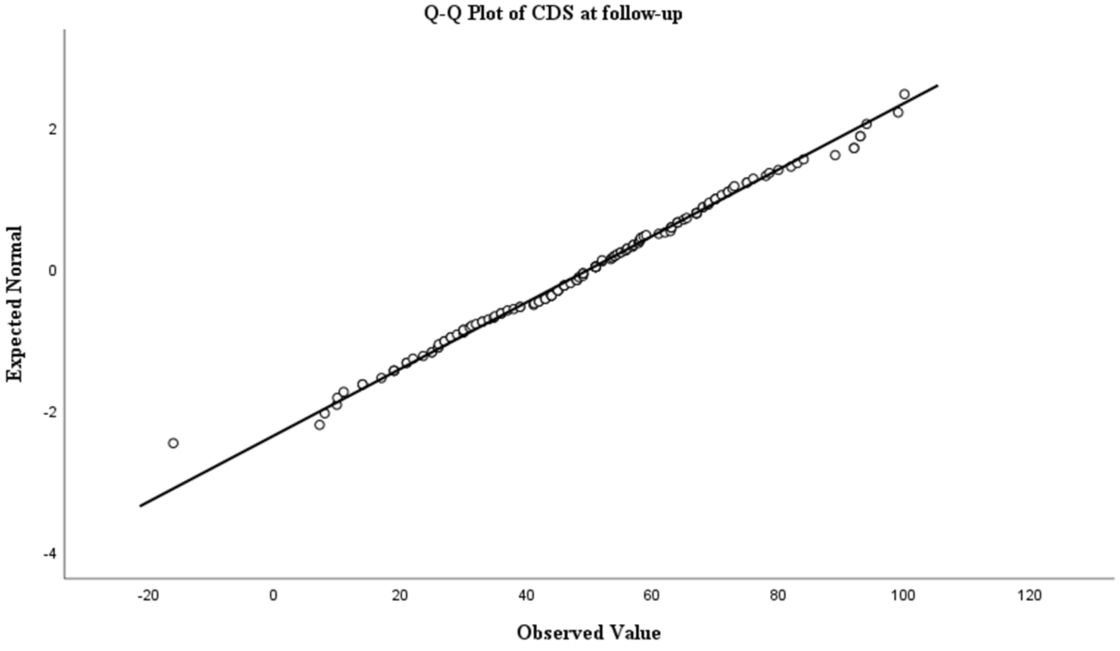


# Appendix E

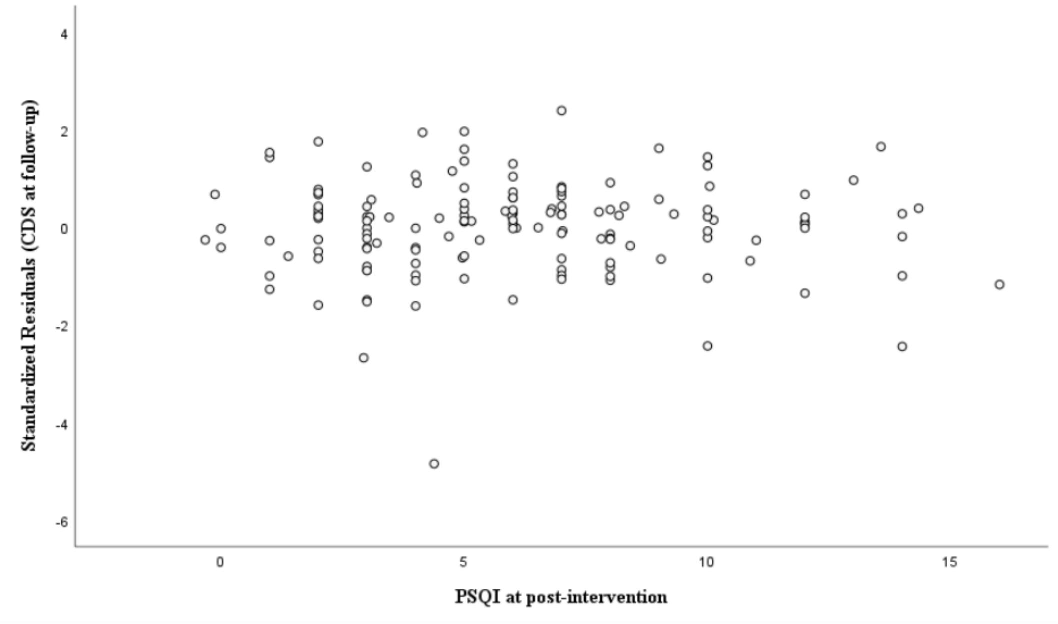
## Figures

### *Assumption Checks for Mediation Analysis*





*Residuals Scatterplot*



# Appendix F

**Table**

*Correlation Matrix of variables in Mediation Analysis*

| Scale | Int | Sex | Educ | Age | P1 | C0 | C2 | F0 | M0 | Lyon | Cologne | Barca |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Int | 1 | | | | | | | | | | | |
| Sex | -.01 | 1 | | | | | | | | | | |
| Educ | .07 | $-.20^{*}$ | 1 | | | | | | | | | |
| Age | -.09 | -.06 | -.08 | 1 | | | | | | | | |
| PSQI1 | .07 | .13 | $-.21^{*}$ | $.24^{**}$ | 1 | | | | | | | |
| CDS0 | .07 | .08 | $-.25^{**}$ | $.22^{**}$ | $.38^{**}$ | 1 | | | | | | |
| CDS2 | .06 | .00 | $-.19^{*}$ | $.25^{**}$ | $.35^{**}$ | $.82^{**}$ | 1 | | | | | |
| FFMQ0 | -.05 | -.15 | $.25^{**}$ | -.05 | -.12 | $-.41^{**}$ | $-.41^{**}$ | 1 | | | | |
| MDRS0 | .13 | .06 | $.25^{**}$ | $-.32^{**}$ | -.05 | -.12 | $-.20^{*}$ | .15 | 1 | | | |
| Lyon | .00 | $.32^{**}$ | -.03 | .04 | .01 | -.06 | -.10 | $-.17^{*}$ | $.17^{*}$ | 1 | | |
| Cologne | -.01 | -.10 | .10 | -.08 | -.01 | -.12 | -.04 | $.17^{*}$ | $.18^{*}$ | $-.37^{**}$ | 1 | |
| Barca | .00 | .04 | .02 | -.08 | -.05 | -.02 | -.09 | -.03 | -.05 | $-.37^{**}$ | $-.37^{**}$ | 1 |

*Note*. Int = Intervention; Educ = Years of Education; PSQI1, P1 = Pittsburgh Sleep Quality Index post-intervention; CDS0, C0 = McNair Cognitive Difficulties Scale baseline; CDS2, C2 = McNair Cognitive Difficulties Scale follow-up; MDRS0, M0 = Mattis Dementia Rating Scale baseline; FFMQ0, F0 = Five Facet Mindfulness Questionnaire baseline. * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant (2-tailed).

# Appendix G

## Mediation Analysis Output

```
***************** PROCESS Procedure for SPSS Version 4.2
*****************

     Written by Andrew F. Hayes, Ph.D.      www.afhayes.com
  Documentation available in Hayes (2022). www.guilford.com/p/hayes3

*****************************************************************
******
Model  : 4
   Y  : CDS2
   X  : Int
   M  : PSQI1

Covariates:
 Sex    Educ    Age    MDRS0   FFMQ0   CDS0    Lyon    Cologne  Barca

Sample
Size:  147

*****************************************************************
******
OUTCOME VARIABLE:
 PSQI1

Model Summary
       R     R-sq      MSE        F      df1      df2        p
     .45      .20    10.76     3.47    10.00   136.00      .00

Model
           coeff       se        t        p     LLCI     ULCI
constant  -12.24    13.38     -.91      .36   -38.71    14.22
Int          .45      .55      .81      .42     -.64     1.54
Sex          .75      .64     1.17      .24     -.52     2.01
Educ        -.13      .08    -1.55      .12     -.29      .03
Age          .10      .04     2.29      .02      .01      .19
MDRS0        .05      .09      .60      .55     -.12      .23
FFMQ0        .03      .04      .66      .51     -.06      .12
CDS0         .06      .02     3.55      .00      .02      .09
Lyon        -.09      .98     -.09      .93    -2.03     1.85
Cologne      .33      .90      .36      .72    -1.46     2.11
Barca       -.13      .88     -.14      .89    -1.87     1.61

Standardized coefficients
           coeff
Int          .13
Sex          .10
```

```
Educ       -.13
Age         .19
MDRS0        .06
FFMQ0        .06
CDS0        .32
Lyon       -.01
Cologne     .04
Barca      -.02

******************************************************************
******
OUTCOME VARIABLE:
 CDS2

Model Summary
      R      R-sq      MSE        F      df1       df2        p
     .83       .68    156.03     26.17     11.00    135.00      .00

Model
          coeff        se         t         p      LLCI      ULCI
constant    72.59     51.12      1.42       .16    -28.51    173.69
Int          .80      2.10       .38       .71     -3.36      4.95
PSQI1       -.11       .33      -.33       .74      -.75       .54
Sex        -2.69      2.44     -1.10       .27     -7.51      2.14
Educ        -.33       .31     -1.06       .29      -.95       .29
Age          .31       .17      1.87       .06      -.02       .65
MDRS0       -.38       .35     -1.11       .27     -1.07       .30
FFMQ0       -.42       .17     -2.48       .01      -.75      -.08
CDS0         .72       .06     11.54       .00       .60       .85
Lyon       -3.11      3.73      -.83       .41    -10.49      4.28
Cologne     -.25      3.44      -.07       .94     -7.06      6.55
Barca      -1.92      3.35      -.57       .57     -8.55      4.70

Standardized coefficients
         coeff
Int         .04
PSQI1       -.02
Sex        -.06
Educ       -.06
Age         .10
MDRS0       -.06
FFMQ0       -.14
CDS0        .70
Lyon       -.07
Cologne     -.01
Barca      -.04

************************* TOTAL EFFECT MODEL
***************************
OUTCOME VARIABLE:
```

```
 CDS2

Model Summary
      R     R-sq      MSE        F      df1      df2        p
    .82      .68   155.01    28.96    10.00   136.00      .00

Model
          coeff       se        t        p     LLCI     ULCI
constant   73.92    50.80     1.46      .15   -26.53   174.38
Int          .75     2.09      .36      .72    -3.39     4.88
Sex        -2.77     2.42    -1.14      .25    -7.55     2.02
Educ        -.32      .31    -1.03      .30     -.93      .29
Age          .30      .16     1.84      .07     -.02      .63
MDRS0       -.39      .34    -1.13      .26    -1.07      .29
FFMQ0       -.42      .17    -2.51      .01     -.75     -.09
CDS0         .72      .06    12.00      .00      .60      .84
Lyon       -3.10     3.72     -.83      .41   -10.46     4.26
Cologne     -.29     3.43     -.08      .93    -7.07     6.49
Barca      -1.91     3.34     -.57      .57    -8.52     4.70

Standardized coefficients
          coeff
Int         .04
Sex        -.06
Educ       -.05
Age         .10
MDRS0      -.07
FFMQ0      -.14
CDS0        .69
Lyon       -.07
Cologne    -.01
Barca      -.04


************** TOTAL, DIRECT, AND INDIRECT EFFECTS OF X ON Y
**************

Total effect of X on Y
     Effect       se        t        p     LLCI     ULCI     c_ps
        .75     2.09      .36      .72    -3.39     4.88      .04

Direct effect of X on Y
     Effect       se        t        p     LLCI     ULCI    c'_ps
        .80     2.10      .38      .71    -3.36     4.95      .04

Indirect effect(s) of X on Y:
         Effect   BootSE  BootLLCI  BootULCI
PSQI1      -.05      .28      -.64       .55

Partially standardized indirect effect(s) of X on Y:
```

```
      Effect    BootSE   BootLLCI   BootULCI
PSQI1      .00       .01      -.03       .03

*********************** ANALYSIS NOTES AND ERRORS
************************

Level of confidence for all confidence intervals in output:
  95.0000

Number of bootstrap samples for percentile bootstrap confidence intervals:
  5000

NOTE: Standardized coefficients for dichotomous or multicategorical X are in
    partially standardized form.

------ END MATRIX -----
```