# Mindfulness and meditation: Treating cognitive impairment and reducing stress in dementia

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**Abstract:** This study investigates the relationship between mindfulness, meditation, cognition and stress in people with Alzheimer's disease (AD), dementia, mild cognitive impairment and subjective cognitive decline. Accordingly, we explore how the use of meditation as a behavioural intervention can reduce stress and enhance cognition, which in turn ameliorates some dementia symptoms. A narrative review of the literature was conducted with any studies using meditation as an intervention for dementia or dementia-related memory conditions meeting inclusion criteria. Studies where moving meditation was the main intervention were excluded due to the possible confounding of exercise. Ten papers were identified and reviewed. There was a broad use of measures across all studies, with cognitive assessment, quality of life and perceived stress being the most common. Three studies used functional magnetic resonance imaging to measure functional changes to brain regions during meditation. The interventions fell into the following three categories: mindfulness, most commonly mindfulness-based stress reduction (six studies); Kirtan Kriya meditation (three studies); and mindfulness-based Alzheimer's stimulation (one study). Three of these studies were randomised controlled trials. All studies reported significant findings or trends towards significance in a broad range of measures, including a reduction of cognitive decline, reduction in perceived stress, increase in quality of life, as well as increases in functional connectivity, percent volume brain change and cerebral blood flow in areas of the cortex. Limitations and directions for future studies on meditation-based treatment for AD and stress management are suggested.

**Keywords:** Alzheimer's disease; dementia; mild cognitive impairment (MCI); mindfulness; neural studies; stress.

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## Introduction

### Alzheimer's disease

Alzheimer's disease (AD) is a terminal neurodegenerative disease and is the most common form of dementia. Supporting this, AD is suggested as accounting for 60%–80% of cases of dementia (Alzheimer's Association, 2016). Worldwide, the disease is estimated to affect over 46 million people (Alzheimer's Disease International, 2015). A recent report released by Alzheimer's Australia and the University of Canberra estimates that dementia currently affects over 400 000 Australians (Brown et al., 2017). It is expected that the morbidity rates of AD will almost double over the next 20 years (Australian Bureau of Statistics, 2014). As such, it is highlighted that dementia is becoming the leading cause of death in Australia.

Currently, there is no specific cure for AD. Instead, to manage the disease, pharmacological treatments slow the progression of cognitive decline for 6–12 months in roughly 50% of AD patients (Alzheimer's Association, 2017). In search for additional and more effective methods to alleviate the burden of AD without the consequences of adverse events such as gastrointestinal issues, there are a large number of studies exploring non-pharmacological treatment approaches towards AD (Paller et al., 2015).

There are many cognitive processes that tend to be affected or impaired over the progression of AD. Mild cognitive impairment (MCI) and subjective cognitive decline (SCD) have been proposed as prodromal stages of AD (Larouche et al., 2015; Smart et al., 2016). The rate of

conversion from amnestic MCI to AD is estimated to be as high as 80% over a 6-year period (Petersen et al., 2001). Therefore, early intervention is crucial at the onset of symptoms as suggested by many studies that attempt to treat AD using pharmacological approaches such as donepezil (e.g. Chang et al., 2015). In support of early intervention, treatment effectiveness tends to be reported higher during the early stages of AD (Seltzer et al., 2004; Chang et al., 2015) by slowing disease progression. Regarding treatment, effectiveness may depend on brain regions commonly affected by the disease.

Both AD and MCI have pronounced effects on many regions of the brain (Newberg et al., 2014; Larouche et al., 2015). The deterioration of brain activity in AD arguably begins in the hippocampus, a part of the limbic system located in the medial temporal lobe, areas primarily associated with memory and emotion. Deterioration then spreads to other regions, eventually affecting the whole brain glucose metabolism, resulting in reduced neuronal processing, particularly in the bilateral parietal and temporal lobes (Newberg et al., 2014). The temporal lobe is primarily associated with episodic memory, emotion and mood (Campbell and MacQueen, 2004; Phelps, 2004) while the parietal lobe is associated with sensation, self-awareness, attention, memory retrieval and theory of mind (Mesulam, 1983; Saxe and Kanwisher, 2003; Wagner et al., 2005). Both areas contribute to the default mode network (DMN), which is adversely affected in the early stages of AD (Greicius et al., 2004; Sorg et al., 2007). Thus, it could be suggested that the brain regions affected by AD (e.g. the hippocampus, parietal and temporal lobes) may share something in common, including their role of regulating emotion, memory and awareness.

## Stress, cognition and dementia

Stress is generally used as an umbrella term and differs across contexts. However, in this paper, it will be discussed in terms of situations where individuals are confronted with aversive stimuli that lead to a negative physiological change (Kim and Diamond, 2002). Further discussed will be how stress has deleterious effects on the hippocampus structurally and functionally over age. Later integrated will be the negative implications of stress on cognition regarding MCI, dementia and AD.

Individuals in stressed states may experience depression that is accompanied by neuronal atrophy in the hippocampus (Duman, 2002). Adult individuals who have experienced severe early childhood abuse involving stress are shown to have a 12% reduction in left hippocampal volume compared to individuals who have not experienced abuse (Bremner et al., 1997). Reduced left side hippocampal volume has similarly been found in adult women who were sexually abused during childhood (Stein et al., 1997). Such findings therefore suggest that most individuals who have been emotionally neglected during childhood are at risk of developing or develop major depressive disorder and, show reduced white matter in their left hippocampi as well as smaller hippocampal head volumes (Frodl et al., 2010; Carballedo et al., 2012). Similar cases have also been found in adults who developed posttraumatic stress disorder (PTSD) after childhood mistreatment in which they revealed small hippocampal volume (Weniger et al., 2008) and atrophy associated with worsened functioning in memory recall (Utto et al., 1993). Therefore, several studies provide evidence on the relationship between stress (and stress-related emotional states such as depression) and increased release of cortisol affecting hippocampal structure and function.

In addition to the hippocampus, smaller volumes have been found in the anterior cingulated cortex and caudate (Cohen et al., 2006), including reductions in the left dorsomedial prefrontal cortex (van Harmelen et al., 2010). However, childhood maltreatment alone cannot provide support for altered hippocampal volume since some individuals do not show such alteration but only demonstrate worsened learning and memory functions (Golier et al., 2005). Explaining this relation between functional disruptions could be chronic and artificial extreme elevated or reduced cortisol levels impairing learning and memory (Young et al., 1999; Lupien et al., 2002). Further, the age at which traumatic or stressful childhood events occur plays a major role in the development of psychiatric disorders (e.g. PTSD). This in turn affects hippocampal development and disruption of the stress response (Frodl and O'Keane, 2013). This is supported by studies that have found that babies born to mothers who experience high levels of stress during pregnancy have less emotional responsiveness and produce increased amount of cortisone as a response to stress (Davis et al., 2011; Field, 2011), indicating sensitive stress response systems (Frodl and O'Keane, 2013). Furthermore, this could include disruption to the development of the hippocampus as stress and cortisone are found to affect synaptic plasticity, hippocampal dendritic morphology (especially damage to apical dendrites in CA3 pyramidal neurons) and, reduced neurogenesis in adult brains consequently leading to memory impairments (Kim and Diamond, 2002; McEwen, 2000).

To further discuss the effects of early experiences over the lifespan in focus, Brunson et al. (2005) explored whether early psychological stress in rats had an impact

on hippocampal functioning overtime (from young adulthood to middle age). Measures included synaptic function and plasticity and substrates of learning and memory essential for hippocampal functioning. Findings of the study included worsened hippocampal-related cognitive functions such as learning and memory, along with long-term potentiation being affected in the CA3 and CA1 regions. Moreover, in older aged individuals, stress initiating extreme levels of cortisone speeds the process of age-related cognitive decline and increases the chances of hippocampal neuronal damage (McEwen and Sapolsky, 1995; Kim and Yoon, 1998; de Kloet et al., 1999; McEwen, 2000). Glucocorticoid receptor activation by cortisone and stress reduce hippocampal plasticity, thus affecting learning and memory, especially spatial memory (de Kloet et al., 1999; Kim and Diamond, 2002). Thus, it could be suggested from these findings that early life stress damages the hippocampus progressively, showing how stress can lead to cognitive decline and age-related neurodegenerative diseases such as dementia.

Distress is also related to the development of AD, including its faster rate of progression (Wilson et al., 2011). Supporting these findings, definite dementia diagnosis and worsened cognition are reported in elderly individuals with long-term distress (Wilson et al., 2007a,b). Further, distress triggers the release of the hormone cortisol, which relates to the function of the hippocampus. It has also been found that with increased distress and the release of excess cortisol, episodic memory becomes impaired (Buchanan et al., 1999; Gurvits et al., 1996; McEwen, 2000; Archer et al., 2009; Wilson et al., 2007a,b). The production of cortisol in excess is reported to result in decreased right hippocampi and orbitofrontal cortex volume (Gianaros et al., 2007). The next section explores how mindfulness may help reduce stress and thus possibly ameliorate cognitive decline in dementia.

## Mindfulness

Mindfulness has been defined as 'Paying attention in a particular way: on purpose, in the present moment, and non-judgmentally' (Kabat-Zinn, 1990). In Buddhism, mindfulness is an essential part of the religion, contributing to the Noble Eightfold Path to Enlightenment (Santina, 1997). Western interpretations of mindfulness incorporate mindfulness meditation techniques into structured learning programs that are secular in nature. For example, mindfulness-based stress reduction (MBSR) developed by Jon Kabat-Zinn, a US-based medical practitioner, was initially designed to help patients manage pain (Kabat-Zinn, 1982). It follows an 8-week format where participants learn a variety of mindfulness meditation techniques over the course of the program (Kabat-Zinn, 1990).

A recent meta-analysis has shown that meditation, including mindfulness meditation, consistently alters a number of brain regions in healthy populations of experienced and novice meditators. These areas include the hippocampus, the frontopolar cortex, the sensory cortices and insula, the anterior cingulate cortex, mid-cingulate cortex, orbitofrontal cortex, superior longitudinal fasciculus and corpus callosum (Fox et al., 2014). Focusing on the benefits that mindfulness has on the brain overall, research suggests that MBSR increases grey matter in the left hippocampus, posterior cingulated cortex and the temporoparietal junction and cerebellum (Hölzel et al., 2011), as opposed to the implication of stress, which tends to reduce hippocampal volume (Gianaros et al., 2007). Therefore, since the hippocampus is involved in memory, emotional regulation such as stress and depression among others, MBSR is understood as an effective approach to managing AD and the resulting emotional challenges involved.

Moreover, mindfulness has been found to increase emotion regulation and reduce anxiety and depression (Tang et al., 2015), which are suggested to also reduce stress (Nima et al., 2013). Thus, by overcoming these negative emotional states through methods of mindfulness and meditation, AD symptoms can perhaps be managed using nonpharmacological interventions (NPIs). A recent review by Berk et al. (2016) examined six studies measuring the effects of a mindfulness intervention on the cognitive capacities of older adults. The review found that mindfulness interventions had a positive effect on some cognitive tests in most studies. However, these positive effects were either small or not present in healthy older adults. Small study sizes and the lack of sensitivity of the cognitive tests were highlighted as limitations in the studies reviewed. Such limitations could suggest that if done using larger sample sizes, mindfulness may yield stronger positive impacts on more cognitive domains and also benefit older cognitively healthy individuals. Another type of mediation has also been recently examined in the management of AD. Kirtan Kriya (KK) meditation is a set of chanting and breathing techniques that is part of the Kundalini Yoga tradition. It involves the repetition of the phrase 'Sa Ta Na Ma' over a period of time (around 15–30 min) along with accompanying hand movements. Kundalini Yoga is influenced by Hindu principles and was brought to the West by Yogi Bhajan.

A review regarding the effects of mediation on stress and AD pathology was conducted by Khalsa (2015).

This review focused on KK as a way to reduce stress and increase cognition in patients with MCI and SCD. It reported that practicing KK reduced many AD risk factors, including a reduction in depression, increased sleep quality and improved quality of life (QOL). Moreover, other researchers investigating the effects of mediation on cognitive decline in older adults report meditation as offsetting cognitive decline (Gard et al., 2014). Other reviews, although limited by the number of available studies, have focused on the potential of meditation as a treatment for older adults with cognitive decline based on brain changes in long-term meditators (Luders, 2014) or the overlap in brain areas affected by meditation and neurodegenerative diseases found in neuroimaging studies (Newberg et al., 2010). Another review conducted by Larouche et al. (2015) investigated the potential benefits of mindfulness-based interventions (MBIs) for people with MCI and AD. This review proposed a model relevant in the exploration of mindfulness and meditation on AD in line with the allostatic load theory. This theory outlines how chronic stress builds up over time, causing wear and tear to the body and brain. It is suggested that conversion from AD risk to probable AD development including MCI could be moderated or prevented using MBIs that reduce a wide range of factors that lead to allostatic load. Considering that mindfulness and other types of meditation could reduce both brain atrophy and the resultant cognitive and mood deficiencies seen in patients with MCI and AD, this review aims to search the literature exploring methods of mindfulness and meditation as promising and fast developing areas of research in AD management.

## Methods

A broad search was conducted of the PubMed and PsychINFO databases for journal articles ranging from the date of inception to the date of writing (1 February 2017). The search terms used were 'mindful*' OR 'meditation' AND 'Alzheimer*' OR 'mild cognitive impairment' OR 'dementia.' It was decided to keep the search terms broad and search all text so as to catch all relevant studies. Results of the search identified 102 original research articles. Abstracts were inspected and articles were excluded if they did not include participants with any form of dementia or MCI and did not use any type of meditation; were in a language other than English; used exercise as a key element of the study; did not measure any cognitive-, stress- or QOL-related variables; or did not include enough information to tell if the intervention was a form of meditation. Ten relevant studies were identified after applying the exclusion criteria. These studies focused on mindfulness or meditation as a treatment for AD, MCI, dementia or SCD. Of the 10 studies, three were randomised controlled trials (RCTs), with one being a longitudinal RCT (LRCT). Figure 1 represents a flowchart of the study selection process. Table 1 presents an overview of the 10 studies of focus.

## Results

The findings of this study included one LRCT measuring the effects of meditation on the cognitive capacities of older individuals experiencing memory loss associated with AD (Quintana-Hernández et al., 2016). The remaining nine studies can be classified as either pilot or feasibility studies. The LRCT study strongly supports the findings of the nine other pilot/feasibility studies that suggest that meditation has a wide range of benefits for AD, MCI and dementia patients.

Quintana-Hernández et al. (2016) conducted a longitudinal, non-inferiority and equivalence RCT with 120 participants diagnosed with AD and being treated with donepezil. All participants scored ≥18 on the Mini-Mental Status Examination (MMSE). There were three experimental groups: mindfulness-based Alzheimer's stimulation (MBAS), a program based primarily on MBSR with the addition of KK meditation and elements of mindfulness-based elder care, multi-sensorial stimulation exercises and chair yoga; cognitive stimulation therapy (CST); progressive muscle relaxation (PMR); and a control group of treatment as normal. Over the course of 2 years, participants in the experimental groups participated in three weekly sessions of intervention. Pre and post cognitive assessments were carried out using the Cambridge Examination for Mental Disorders of the Elderly and Mini-Mental State Examination

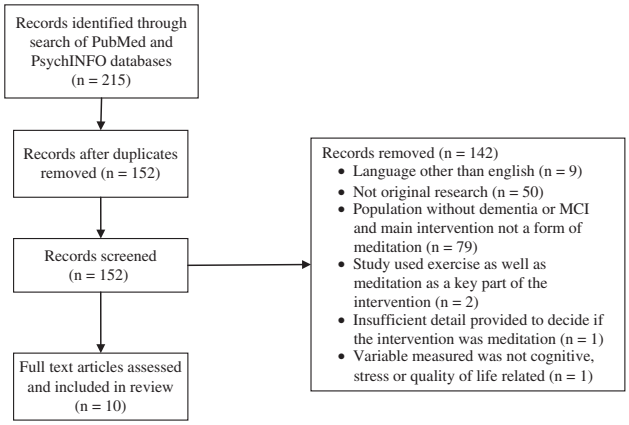


**Figure 1:** Flow diagram.

**Table 1:** Overview of studies on mindfulness, mediation and relationship to AD symptoms.

| Author | Population type | Experimental group | Control group included | Variable measured | Significant findings | Study type and study size | Apolipoprotein E gene tested for |
|---|---|---|---|---|---|---|---|
| Quintana-Hernández et al. (2016) | AD | Three treatment groups – mindfulness-based Alzheimer's stimulation, cognitive stimulation and PMR. All groups involved three treatment sessions per week carried out for 2 years | Yes | Cognitive assessment: CAMDEX-R, including the MMSE and CAMCOG | Mindfulness and cognitive stimulation groups had significantly better scores on cognitive assessments Mindfulness effect size ($p \geq 0.80$) | Longitudinal, noninferiority and equivalence, randomized clinical trial n = 120 | Yes |
| Wells et al. (2013b) | MCI | Mindfulness (MBSR) 8 weeks (reported home practice, $M = 26$ min/day) One treatment group | Yes | Functional connectivity in the DMN and hippocampal atrophy measured using fMRI scans | Significant increase in functional connectivity between brain regions. Trends towards significant hippocampal volume difference favouring the mindfulness group | Pilot study n = 14 | No |
| Wells et al. (2013a) | MCI | Mindfulness (MBSR) 8 weeks (reported home practice, $M = 26$ min/day) | Yes | ADAS-cog and standardized QOL | No significant results. Trends towards improvement on the ADAS-cog test | Pilot study n = 14 | No |
| Paller et al. (2015) | AD, n = 9; MCI, n = 2; multiple strokes, n = 2; memory complaints without clinical diagnosis, n = 3; frontotemporal dementia, n = 1; and their caregivers, n = 20 | Mindfulness 8 weeks Program developed mainly from MBSR with elements of dialectical behaviour therapy and acceptance and commitment therapy | No | QOL in AD, Geriatric Depression Scale, Pittsburgh Sleep Quality Inventory, Beck Anxiety Inventory, TMT A and B, Repeatable Battery for the Assessment of Neuropsychological Status and posttreatment questionnaire | Significant improvement in quality of life ($p = 0.001$) and a decrease in depressive symptoms ($p = 0.49$). No significant improvement in any of the cognitive tests | Patients with cognitive decline, n = 17; caregivers, n = 20 | No |
| Smart et al. (2016) | SCD | Two treatment groups – MT (MBSR tailored to older adults) and PE | No | EEG, fMRI, self-report measures of psychological functioning | Increase in percent volume brain change. Decrease in cognitive complaints and an increase in memory self-efficacy. EEG results also appeared positive | Pilot randomized controlled trial n = 36 (SCD, n = 14; without SCD, n = 22) | No |
| Innes et al. (2016a) | SCD (including MCI) | Two treatment groups – Meditation (KK) 12 weeks, 12 min a day, and ML 12 weeks, 12 min a day | No | Recruitment and retention rates, attendance, practice adherence, treatment expectancy and patient experience of the study | Retention rate, 92% Adherence, 93% Likely or very likely to continue practice, 87% 74% found the program relaxing, calming, peaceful or uplifting | Acceptability and feasibility study n = 60 | No |

**Table 1** (continued)

| Author | Population type | Experimental group | Control group included | Variable measured | Significant findings | Study type and study size | Apolipoprotein E gene tested for |
|---|---|---|---|---|---|---|---|
| Innes et al. (2016b) | SCD (including MCI) | Two treatment groups – meditation (KK) 12 weeks, 12 min a day, and ML 12 weeks, 12 min a day | No | Perceived stress, mood, sleep and health-related QOL | Both groups showed significant increases in mood, sleep quality and some psychological measures ($p = 0.05$) | RCT n = 60 | No |
| Innes et al. (2012) | AD | Meditation (KK) 8-weeks, 11 min twice a day | No | Perceived Stress Scale, Dispositional Resilience Scale, General Sleep Disturbance Scale, Profile of Mood States. Memory Functioning Questionnaire. PANAS, Self-Compassion Scale and blood pressure | Significant improvement in perceived stress ($p = 0.03$), sleep quality ($p = 0.02$), retrospective memory function ($p = 0.04$) and systolic blood pressure ($p = 0.004$) | Pilot study AD, n = 6; caregivers, n = 6 | No |
| Newberg et al. (2010) | Age-associated memory impairment, n = 7; MCI, n = 5; moderate AD, n = 3 | Two treatment groups – Meditation (KK) 8 weeks, 12 min a day, and ML 8 weeks, 12 min a day | No | CBF measured with fMRI, a battery of neuropsychological tests, WAIS, Digit Symbol Substitution Test, Logical Memory task, Trails A and B and a category fluency task in which subjects named as many animals as possible in 60 seconds | Significant increases ($p < 0.05$) in baseline CBF ratios in the prefrontal, superior frontal and superior parietal cortices. Significant improvement in the category fluency task. Trends towards significance in the Trials B task, the WAIS and the logical memory task | Preliminary study n = 15 | No |
| Lenze et al. (2014) | SCD and anxiety-related distress | Mindfulness (MBSR) One group: 8-week program; One group: 12-week program | No | A battery of cognitive tests (RBANS, CVLT, DKEFS, verbal fluency test), Penn State Worry Questionnaire – Abbreviated | Significant increase in cognitive performance on four out of seven measures. Worry-severity showed a significant reduction ($p = 0.001$) and a large effect size | Pilot study n = 12 | No |

(CAMDEX-R, MMSE and Cambridge Cognition Examination [CAMCOG]). To assess the non-inferiority of MBAS, the rationale for choice of the comparative treatments were as follows: CST, because it is currently the most widely used non-pharmacological treatment, and PMR, to ascertain if mindfulness provided any benefit in addition to muscle relaxation. Patients in all the groups continued their regular treatment with donepezil. The control group comprised treatment with donepezil as normal. There was no significant difference between the groups on any of the sociodemographic or clinical variables except for dyslipidaemia in the PMR group. There was no significant difference in scores between groups on the MMSE at baseline. However, there was a significant difference in CAMCOG scores favouring the CST group compared to the PMR and control groups in patients with mild-moderate AD at baseline. For moderate-severe AD patients, no significant difference was found between treatment groups. Results for mild-moderate stages of AD showed that the mindfulness group had significantly better scores on the cognitive tests than the PMR and control groups did and was equal with the CST group. Statistical analysis of the data from groups overall indicated substantially larger effect favouring the MBAS treatment over CST. Furthermore, over the course of the 2-year treatment, the MBAS group suffered no significant deterioration on any of the cognitive capacities assessed. In the CST group, capacities started to deteriorate after 18 months. In the PMR and control groups, capacities deteriorated after only 6 months. In summary, both MBAS and CST are significantly and clinically superior to treatment with donepezil alone or in conjunction with PMR in the mild-moderate stage of AD. Thus, findings of this study highlight MBAS as at least equivalent to CST in the treatment of mild-moderate AD, possibly with even greater long term efficacy.

Lenze et al. (2014) studied MBSR as a treatment for worry symptoms and SCD in an elderly population suffering from clinically significant anxiety (n = 34; mean age = 70.8 years). The study focused on both the acceptability of MBSR to this population and its effect on various cognitive and mood measures. One group used a modified MBSR program, with the length of the study increased from 8 to 12 weeks and the prescribed 1-day retreat shortened to 2.5 h. A second group used the standard 8-week MBSR treatment. The measures included cognitive tests repeatable battery for the assessment of neuropsychological status (RBANS), California verbal learning test (CVLT), Delis–Kaplan executive function scale (DKEFS) and verbal fluency tests administered at baseline and post intervention. A clinical measure of anxiety-related distress was administered at baseline, midway through the MBSR course, at completion of the course and 2 and 6 months post course (Penn State Worry Questionnaire – Abbreviated). A measure of mindfulness was also administered pre and post intervention (Cognitive Affective Mindfulness Scale – Revised). All cognitive outcome measures showed a trend towards improvement with a significant increase in cognitive performance on four out of seven measures. The two word-recall tasks showed large effect sizes ($d = 0.75$ and $d = 0.83$), and anxiety-related distress showed a significant reduction and a large effect size ($p = 0.001$; $d = 0.86$). This was a clinically significant drop below the threshold level for generalized anxiety disorder in older adults. Other findings included significant increase in self-reported mindfulness ($p = 0.02$; $d = 0.76$). However, the modified 12-week MBSR program revealed no advantage over the standard 8-week program. At 6 months, the majority of participants (59%) continued mindfulness techniques, including formal meditation, which reduced stress. While there were a number of limitations to this study, including the lack of an active control group and the small sample size, the results are promising and should encourage further investigation.

Newberg et al. (2010) measured the effects of an 8-week intervention of KK meditation, practiced each day for 12 min (n = 15; mean age = 64 years). Participants of the study experienced memory loss that was age associated to memory impairment (n = 7; MCI n = 5; moderate AD, n = 3) as supported by MMSE scores ranging from 16 to 30. A control group of five participants (MCI, n = 2; age-associated memory loss, n = 3) were given classical music to listen to for 12 min each. Outcomes measured included cerebral blood flow (CBF) using functional magnetic resonance imaging (fMRI) single photon emission computed tomography (SPECT) and a battery of neuropsychological tests: Wechsler Adult Intelligence Scale (WAIS) Digit Symbol Substitution Test, a logical memory task, Trails A and B and a category fluency task in which participants named as many animals as possible in 60 seconds. Upon completion of the KK program, participants' CBF showed improvements particularly in the frontal lobe regions and the right superior parietal lobe ($p < 0.05$). In the music listening (ML) group, there were trends towards significance in CBF in the amygdala and precuneus. After analysis and correction for multiple comparisons on the battery of neuropsychological measures, only the category fluency task showed a significant improvement ($p < 0.01$). However, there were trends towards significance in the Trials B task and WAIS, indicating that there were some improvements in visual attention, executive function (switching) and cognitive abilities that could be further investigated using longer term meditation practices.

Smart et al. (2016) investigated whether mindfulness training (MT) is both useful and feasible as an

early intervention for individuals with SCD. Participants included in this study comprised of two treatment groups, one of MT and one of psychoeducation (PE), each including participants with SCD and healthy controls (HCs). Participants from the HC and SCD groups intermixed for the purpose of treatment so that they were blind to their own diagnostic group. The MT condition used MBSR specifically tailored for older adults. It involved an 8-week program comprising weekly 2-h sessions and home practice facilitated by a guided CD and workbook. The PE condition used the 'Memory and Aging Program' and was a 5-week program of weekly 2-h sessions. The difference in time between the two programs was due to the optimal 'dose' as set out in the empirically validated manual for each program. The first hypothesis (based on previous findings by Zylowska et al., 2008; Azulay et al., 2013; Smart et al., 2014) was that MT would increase P3 event-related potential (ERP) amplitude measured by electroencephalography (EEG) in both HC and SCD participants. However, this increase would be more pronounced in the population with SCD because their P3 ERP would be lower at baseline. The second hypothesis attempted to measure objective behavioural performance on a Go/No Go task. Prediction of this task included MT group participants showing reduced reaction time intra-individual variability, implying a more stable moment-to-moment attention. The third hypothesis was that the MT group would show an increase in percent volume brain change in comparison to the PE group measured on a pre/post-test magnetic resonance imaging brain scan. The fourth and final hypothesis was that participants in the MT group would show an improvement in self-reported psychological function on indexes of self-efficacy, cognitive complaints and mindfulness when compared to the control group. Findings of the study revealed that on the P3 ERP measures, the SCD group showed a significant effect favouring the MT group ($p = 0.047$). On the other hand, there was no significant change in the HC group favouring MT or PE. In the SCD group, MT was effective to the extent that SCD participants' P3 amplitude increased to similar levels as that of the HC, showing a significant increase from baseline. Moreover, fMRI scans showed an increase in percent volume brain change in the MT group compared to the PE group ($p = 0.009$). No significant interaction was observed between the HC and SCD groups. The study's authors suggest that this may be from the reduction in sample size due to motion artefacts and other difficulties with data collection, resulting in a sample size of only 14 participants (SCD and HC = 7 each; MT = 8, PE = 6). To summarise the study's findings, all participants with SCD reported a decrease in cognitive complaints and an increase in memory self-efficacy as well an increase in P3 ERPs, implying increased attention capacity. This is supported by the measure of reaction time indicating a significant effect.

Wells et al. (2013a) conducted a randomized controlled pilot study involving 14 MCI participants, aged between 55 and 90 years. Participants were randomly allocated 2:1 to an MBSR group and a control group. The groups did not differ on the baseline measure on the MMSE (mean = 27). The MBSR intervention ran for 8 weeks and involved a 2-h, once-a-week practice and one full day of mindfulness retreat. In addition, home practice of 30 min/day was encouraged (reported home practice, mean = 26 min/day). Mindfulness was defined as 'non-judgemental moment to moment awareness.' The *a priori* hypotheses based on previous research into MBSR were as follows: MBSR would increase regional functional connectivity in the area of the DMN, specifically the medial prefrontal cortex (MPFC), hippocampus and posterior cingulate cortex (PCC), and that MBSR would slow the rate of hippocampal atrophy measured by fMRI at baseline and 8 weeks.

Findings of the study included MBSR treatment significantly increasing functional connectivity in the DMN and reducing hippocampal atrophy in MCI participants. Moreover, the MBSR group showed a significant increase in functional connectivity between the PCC and bilateral MPFC and between the PCC and left hippocampus compared to the control group ($p \leq 0.005$). Bilateral hippocampal volume difference from baseline to follow-up trended toward significantly less atrophy for the MBSR group compared to the control group ($p = 0.07$). The results of the study indicated that MBSR may have a positive impact on brain areas affected in AD and MCI, in particular, the hippocampus and DMN. Due to small sample size, strong conclusions about the effect of MBSR on DMN function cannot be drawn. However, the results point in a promising direction.

Wells et al. (2013b) reports on a number of different variables that were measured in Wells et al. (2013a). Batteries of neuropsychological measures were administered to participants at baseline and 8 weeks. The tests were the Alzheimer's Disease Assessment Scale, cognitive subscale (ADAS-cog), standardized QOL and the well-being questionnaires. Semi-structured interviews were also conducted with the MBSR group. There were no significant increases in the MBSR group on any measures; however, trends towards improvement were reported in the ADAS-cog test. This may suggest that continuation with the program for longer than 8 weeks would result in significant improvements in aspects of cognition. Regarding the psychological findings of the study, participants reported

enjoying the program and described improved mindfulness skills, well-being, interpersonal skills, acceptance and awareness of cognitive impairment (i.e. insight of disease).

Innes et al. (2012) conducted a pilot study investigating the effects of a KK meditation intervention on six participants diagnosed with MCI or early-stage AD. Outcomes measured were Perceived Stress Scale, Dispositional Resilience Scale, General Sleep Disturbance Scale, Profile of Mood States, Memory Functioning Questionnaire, Positive and Negative Affect Scale (PANAS), Self-Compassion Scale and blood pressure. Participants also completed a treatment expectancy questionnaire and a short exit questionnaire. The intervention involved participants completing 11 min of meditation twice a day for 8 weeks (mean meditation sessions per week = 11.14). Participants were measured at baseline and at the completion of the 8-week program. Results on the exit questionnaire revealed overall positive experiences of enjoyment in the meditation tasks, with only one cognitively impaired participant finding the practice challenging. There were significant improvements in perceived stress ($p = 0.03$), as well as in sleep quality ($p = 0.02$), retrospective memory function ($p = 0.04$) and systolic blood pressure ($p = 0.004$). There was no significant improvement in PANAS, stress hardiness or self-compassion. Therefore, it could be suggested that there are varying findings in this study concerning the effect on participants after the 8-week meditation program.

Paller et al. (2015) looked at the effectiveness of an 8-week mindfulness program on patients with progressive cognitive decline (AD, n = 9; MCI, n = 2; multiple strokes, n = 2; memory complaints without clinical diagnosis, n = 3; frontotemporal dementia, n = 1) and their caregivers (n = 20). Qualitative measures included QOL in AD, Geriatric Depression Scale, Pittsburgh Sleep Quality Inventory, Beck Anxiety Inventory, Trail-Making Tests (TMTs) A and B, Repeatable Battery for the Assessment of Neuropsychological Status and a posttreatment questionnaire scale on whether the participants felt they benefited from the program. In addition, caregivers were tested on the Revised Memory Problem and Behaviour Checklist, Short-Form Health Survey and the Activities of Daily Living Questionnaire. The study also made use of an interview as a qualitative measure. Findings of the study showed statistically significant improvements in the QOL ($p = 0.002$) of participants. Moreover, participants who initially reported sleep disturbance preintervention later experienced improved sleep ($p = 0.41$). However, no significant changes were found for anxiety, patient behaviour, caregiver distress, activities of daily living and caregiver health measures. There were also no significant results in any of the cognitive tests. Of particular interest, results included a high level of perceived benefit, with 84% of participants reporting that the program was beneficial, 89% intending to continue with the mindfulness practice and 89% recommending the program. This supports results from other studies that show elders with cognitive impairment both enjoy and feel they benefit from mindfulness or meditation programs (Wells et al., 2013a,b; Lenze et al., 2014; Innes et al., 2016a,b).

Innes et al. (2016a,b) conducted an RCT to investigate the effects of two relaxation programs (KK meditation and ML). Sixty elderly patients (mean age = 60) with SCD and possible MCI participated in the study over the course of 6 months. Overall, the sample was characterised by a high prevalence of known AD risk factors (e.g. metabolic/vascular risk), with 40% having TMT-B scores in the range suggesting a high risk of conversion to MCI/dementia. Participants were instructed to practice KK or ML for 12 min each day over a period of 12 weeks (93% adherence) and then at their discretion for the following 3 months (71% adherence). Participants were measured at baseline, 12 weeks and 26 weeks. Participants in the KK group showed significant improvements post intervention in perceived stress ($p \leq 0.01$; effect size [ES] = 0.6), three out of four of the constituent domains of the Mental Health component of QOL (overall significance, $p = 0.01$; ES = 0.5), mood ($p \leq 0.01$; ES = 0.9), psychological well-being ($p \leq 0.01$; ES = 0.6) and sleep quality ($p = 0.01$; ES = 0.5). These gains were either stable or increased after 26 weeks, with the exception of sleep quality, which started to decline. In comparison, the ML group experienced significant improvements only in psychological well-being, mood and sleep quality and one of four of the constituent domains of the Mental Health component of QOL. The effect sizes observed in the KK group were all medium to large compared to the small and medium effects in the ML group. Significant differences in KK compared to ML were observed in favour of KK on measures of psychological well-being and the Mental Health component of QOL. While marginally significant results ($p \leq 0.01$) were observed in perceived stress and mood, to summarise, KK is significantly more effective than ML in a number of key domains.

A second study by Innes et al. (2016b) examined the feasibility and acceptability of KK meditation and ML for adults with SCD using the same population as Innes et al. (2016a). The study aimed to measure recruitment and retention rates, attendance, practice adherence, treatment expectancy and patient experience of mediation. Other outcome measures were described in Innes

et al. (2016a). Attrition rates were low, with 92% completing the 12-week program and 88% completing the full 6-month follow-up. Participant adherence was high, with the average participant attending 93% of all possible sessions in the 12-week program and completing 71% of all home practice sessions during the 3-month follow-up (mean sessions/week = 5.0). In the post-program questionnaire, 87% of the KK group and 79% of the ML group indicated likeliness to continue the practice. This percentage dropped to 57% and 76%, respectively, by the end of the 6-month follow-up. Scores from an open-ended post-intervention questionnaire showed that most participants in the KK group found the program relaxing, calming, peaceful or uplifting (74%; compared to the ML group, 52%) and were either likely or very likely to continue the practice (87%, compared to 79%). Therefore, this study supports both the feasibility and acceptability of meditation and ML as interventions for an elderly population with memory complaints.

# Discussion

The current review examined the use and benefits of meditation in the AD literature. Ten studies involving meditation, either mindfulness or KK, as treatments for negative, cognitive, emotional and QOL outcomes for AD, MCI and SCD patients were identified. The review discussed the relationship between these two types of meditation (mindfulness and KK), cognition and stress. Of the six studies that measured the cognitive effects of meditation on these conditions, four had significant findings (Newberg et al., 2010; Lenze et al., 2014; Quintana-Hernández et al., 2016; Smart et al., 2016), while the other two studies had findings that trended towards significance. Possible justification for the insignificant findings of these two studies follows. Wells et al.'s (2013a,b) main aim was to measure percent volume brain difference and was not sufficiently powered to detect cognitive effects, and Paller et al.'s (2015) main aim was to test the effects of mindfulness on overall QOL.

The only published LRCT investigating the effects of meditation on cognitive capacities of AD patients was Quintana-Hernández et al. (2016). This study demonstrated that a meditation intervention based on MBSR and KK (MBAS) was able to meaningfully delay deterioration of cognitive capacities in people with mild to moderate AD. In contrast to previous studies designed as pilot studies or feasibility tests, this study was a longitudinal, non-inferiority RCT, run over a 2-year period. Participant sample sizes used also allowed for all experimental groups to be powered in order to detect changes in cognitive capacities (if present) (Baer, 2003). To our knowledge, this study was the first of its kind in the field of mindfulness and mediation-based research on AD patients. Findings of the study emphasise MBAS as a treatment for the loss of cognitive capacities in AD as statistically non-inferior with substantially larger effect size than cognitive stimulation, which is currently the most commonly prescribed non-pharmacological AD intervention. Over the 2-year period of the study, MBAS effectively prevented the deterioration of cognitive capacities. The effectiveness of MBAS in preventing cognitive deterioration was compared to the dramatic deterioration of capacities in treatment using PMR or pharmacological drugs (donepezil).

A number of the studies reviewed in the present paper provide physiological evidence supporting why meditation may be effective in the maintenance of cognitive capacities in AD. Previous studies into the changes that take place within the brain of healthy meditators have shown that this population has greater hippocampal volume than HCs (Luders et al., 2011; Luders, 2014) and show changes in the DMN (Brewer et al., 2011; Jang et al., 2011; Taylor et al., 2013). Wells and colleagues (2013) were able to replicate such finding in a population with MCI by reporting mindfulness as increasing functional connectivity in the DMN and a trend towards a significant reduction in hippocampal atrophy. In addition, Newberg et al. (2010) found that people with subjective memory decline (53% with AD or MCI) who practiced KK for 8 weeks had significantly improved CBF within the frontal lobe and right superior parietal lobe. This included trends towards significance in a number of other regions when compared to an ML group. Interestingly, the ML group showed a trend towards significant improvements in CBF in the amygdala and precuneus, suggesting the effectiveness of ML in individuals with subjective memory decline. Moreover, Paller et al. (2015) found that mindfulness increases attention as measured by P3-related activity, especially in patients with compromised attention capacity. Although these three studies are small and exploratory in nature, they report findings that indicate an emerging theoretical framework. As such, they may help to describe why mindfulness and meditation have a positive effect on the maintenance of cognitive capacities of SCD, MCI, dementia and AD patients.

## Stress and meditation

As discussed above, stress speeds the progression of AD pathology (e.g. Gianaros et al., 2007; Katz et al., 2016).

Thus, by managing stress, the implications and progression of AD can be improved (e.g. Lenze et al., 2014). In support of such conclusion, KK meditation was reported to improve stress, sleep and memory, as well as systolic blood pressure, in MCI individuals (Innes et al., 2012). Similarly, individuals with cognitive impairment involved in mindfulness programs also experienced improvements in sleep and QOL (Paller et al., 2015). Using ML and KK meditation methods, patients with SCD and possible MCI also reported improved stress, QOL, well-being and sleep, with participants in the KK group showing greater gains in these measures than those in ML (Innes et al., 2016a,b).

The speed of deterioration in cognitive capacities of AD patients is exacerbated by psychological factors, in particular depression (Cherbuin et al., 2015) and stress (Wilson et al., 2011). Previous studies of mindfulness as a treatment for these conditions in other populations have shown that it is effective (Grossman et al., 2004; Hofmann et al., 2010; Innes and Selfe, 2014). The studies reviewed in the current paper further support such findings and demonstrate that mindfulness could be applicable to SCD, MCI, dementia and AD patients as disease management methods.

Four of the currently reviewed studies examined the emotional well-being of patients by measuring depression, worry, perceived stress and mood. Patients who underwent an 8-week mindfulness or KK intervention showed significant reduction in depression (Paller et al., 2015) and worry (Lenze et al., 2014) as well as an increase in positive mood (Innes et al., 2016b). A significant reduction in perceived stress was also found in two other studies (Innes et al., 2012, 2016b). Where QOL and sleep quality were measured, all but one study reported a significant increase in improvement (Innes et al., 2012, 2016b; Paller et al., 2015). The only study to not have a significant finding was Wells et al. (2013b), which was underpowered to accurately detect such an effect.

In three studies that specifically measured the acceptability and feasibility of mindfulness or KK on older populations with SCD, MCI and AD, positive responses were apparent. Innes et al. (2016a) found that 74% of participants found KK to be a positive experience (e.g. relaxing, calming, peaceful or uplifting), and on average, participants attended over 90% of scheduled sessions. Such results support an earlier study that found 90% of participants reported the 8-week meditation intervention to be an overall positive experience (Innes et al., 2012). Moreover, in two studies, 59% and 57% of participants (respectively) reported continued use of the mindfulness techniques after a period of 6 months and found it useful in reducing stress (Lenze et al., 2014; Innes et al., 2016b). Overall, these results suggest that the two types of meditation in the studies reviewed are acceptable and enjoyable experiences of target populations with MCI, dementia, SCD and AD.

## Limitations

There are two main limitations in the studies reviewed. First, results showing positive treatment effects are indicative and not conclusive due to small sample sizes involved in the majority of the reviewed studies. Such limitation is widely acknowledged by the study authors and is accompanied by a call for larger longitudinal controlled trials to establish clear causation such as that undertaken by Quintana-Hernández et al. (2016). Given that the field of research into the use of meditation as a treatment for AD, MCI and SCD is relatively new, small pilot and feasibility studies provide important groundwork. It is hoped that after the positive finding by Quintana-Hernández et al. (2016), more LRCT studies will be undertaken to test the validity of current findings.

A second limitation identified in the reviewed studies is that outcome data have been measured using a wide array of different instruments. As such, drawing firm conclusions from the cumulative results becomes difficult. In addition, most studies measured the effects of meditation after a relatively short, 8-week intervention. Quintana-Hernández et al. (2016) showed that this timeframe may not be sensitive enough to detect the full cognitive effects of a meditation intervention. This is supported by a number of studies showing increases in cognitive capacities trending towards significance (Wells et al., 2013a,b; Paller et al., 2015). Therefore, meditational approaches towards treating AD may need a longer period of time to take effect in improving cognition, although they seem to improve emotional wellbeing (e.g. stress) at a faster rate.

## Suggestions for future research

Additional studies are required to test the effect of meditation on AD and MCI, in particular, as they present a serious burden on patients and the community (e.g. caregivers). The robust findings by Quintana-Hernández et al. (2016) suggest that further LRCTs should be undertaken to test different types of meditation (MBAS, KK and MBSR) as an effective complimentary frontline treatment to donepezil for the cognitive deficits experience by AD patients. The authors suggest that an ideal study might compare MBAS,

CST and ML to each other and, treatment as normal, using cognitive, QOL and mood measures.

As an implication, it would also be of interest to further study differences in the activation of various brain regions between different treatments of meditation. As these treatments have all been shown to be beneficial to some extent in the reviewed studies, such future implication would be ethically appropriate and would provide a standard of comparison to evaluate the best current NPI available for SCD, MCI and AD patients.

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