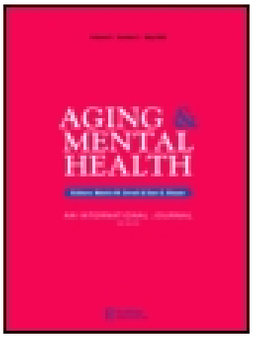
Can mindfulness-based interventions influence cognitive functioning in older adults?



Aging & Mental Health

ISSN: 1360-7863 (Print) 1364-6915 (Online) Journal homepage: http://www.tandfonline.com/loi/camh20

Can mindfulness-based interventions influence cognitive functioning in older adults? A review and considerations for future research

Lotte Berk, Martin van Boxtel & Jim van Os

To cite this article: Lotte Berk, Martin van Boxtel & Jim van Os (2016): Can mindfulness-based interventions influence cognitive functioning in older adults? A review and considerations for future research, Aging & Mental Health, DOI: 10.1080/13607863.2016.1247423

To link to this article: http://dx.doi.org/10.1080/13607863.2016.1247423

AGING & MENTAL HEALTH, 2017
http://dx.doi.org/10.1080/13607863.2016.1247423

Routledge
Taylor & Francis Group

Can mindfulness-based interventions influence cognitive functioning in older adults? A review and considerations for future research

Lotte Berk[a], Martin van Boxtel[a] and Jim van Os[a,b]

[a]Department of Psychiatry and Neuropsychology, School for Mental Health and Neuroscience, Maastricht University, Maastricht, The Netherlands; [b]King's College London, King's Health Partners, Department of Psychosis Studies, Institute of Psychiatry, London, UK

ABSTRACT

Objectives: An increased need exists to examine factors that protect against age-related cognitive decline. There is preliminary evidence that meditation can improve cognitive function. However, most studies are cross-sectional and examine a wide variety of meditation techniques. This review focuses on the standard eight-week mindfulness-based interventions (MBIs) such as mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT).

Method: We searched the PsychINFO, CINAHL, Web of Science, COCHRANE, and PubMed databases to identify original studies investigating the effects of MBI on cognition in older adults.

Results: Six reports were included in the review of which three were randomized controlled trials. Studies reported preliminary positive effects on memory, executive function and processing speed. However, most reports had a high risk of bias and sample sizes were small. The only study with low risk of bias, large sample size and active control group reported no significant findings.

Conclusion: We conclude that eight-week MBI for older adults are feasible, but results on cognitive improvement are inconclusive due a limited number of studies, small sample sizes, and a high risk of bias. Rather than a narrow focus on cognitive training *per se*, future research may productively shift to investigate MBI as a tool to alleviate suffering in older adults, and to prevent cognitive problems in later life already in younger target populations.

ARTICLE HISTORY
Received 9 May 2016
Accepted 9 October 2016

KEYWORDS
Mindfulness; MBSR; MBCT; cognition

Introduction

A growing body of literature supports the efficacy of mindfulness-based interventions (MBIs) in promoting health benefits and psychological well-being for both healthy and clinical populations (Fjorback, Arendt, Ornbøl, Fink, & Walach, 2011; Khoury, Sharma, Rush, & Fournier, 2015). Recently, the potential of MBI to contribute to successful aging has gained interest, also in the context of dementia prevention by targeting stress and other risk factors. This interest was sparked by research in young adults suggesting that mindfulness training could benefit cognitive functioning (see review Chiesa, Calati, & Serretti, 2011). Studies on the effects of meditation on age-related cognitive decline reported effects on attention, memory, executive function, processing speed, and general cognition (Gard, Hölzel, & Lazar, 2014). However, these studies involved a variety of meditation techniques and had a cross-sectional design, making it hard to draw firm conclusions.

There are several pathways by which MBI can influence cognitive aging (see Figure 1). There is preliminary evidence that stress influences the biological aging process (Blackburn & Epel, 2012). Several studies have shown association between MBI, stress, arousal (e.g. high cortisol) and cellular aging (Epel, Daubenmier, Moskowitz, Folkman, & Blackburn, 2009). Mindfulness meditation may result in increased telomerase activity (Schutte & Malouff, 2014). Telomerase enzyme activity influences telomerase length, which is associated with health and mortality (Blackburn & Epel, 2012). Moreover, a randomized controlled trial (RCT) showed that a mindfulness-based stress reduction (MBSR) program in lonely older adults down-regulated pro-inflammatory gene expression (Creswell et al., 2012). MBI in older adults may also impact other risk factors associated with age-related cognitive decline such as depression (Foulk, Ingersoll-Dayton, Kavanagh, Robinson, & Kales, 2014; Gallegos, Hoerger, Talbot, Moynihan, & Duberstein, 2013; Splevins, Smith, & Simpson, 2009; Young & Baime, 2010) and vascular risk factors, such as hypertension (Palta et al., 2012). Mindful meditation may influence brain structure and function (Tang, Hölzel, & Posner, 2015) and a review reported some evidence that meditation may slow down age-related brain degeneration (Luders, 2014). Recently, a study showed reduced age-related degeneration of the hippocampal subiculum, an area known to show reduction of gray matter with normal aging, in long-term meditators (Kurth, Cherbuin, & Luders, 2015). Moreover, a study on adults with Mild Cognitive Impairment (MCI) reported that participants in a MBSR program showed increased functional connectivity in the default mode network compared to control participants (Wells et al., 2013). In addition, MBSR participants showed a trend towards less bilateral hippocampal volume atrophy than controls. These preliminary results, that require replication and systematic review, indicate that in adults with MCI, MBSR may have a positive impact on the regions of the brain most related to MCI and Alzheimer disease. Some studies also report indirect evidence by investigating the protective effect of trait mindfulness. For example, the negative effect of life stress on mental health was weakened for those individuals with higher levels of trait mindfulness (de Frias & Whyne, 2015).

Even though these early reports suggest preliminary evidence that meditation can influence age-related cognitive

CONTACT Lotte Berk lotte.berk@maastrichtuniversity.nl

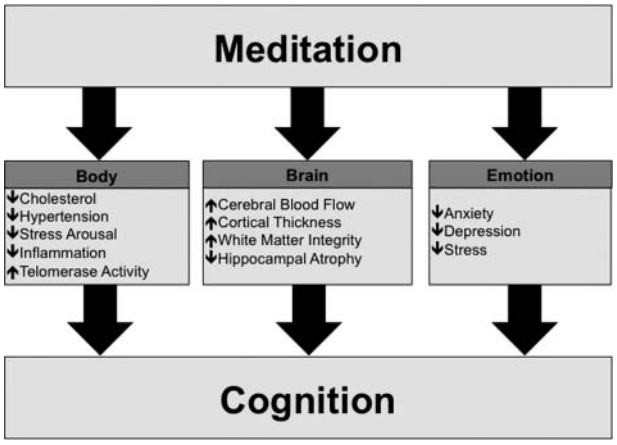


Figure 1. Schematic model for the effects of meditation on cognition. (Adapted from Marciniak et al. (2014).)

decline, it remains unclear what can be expected from a standard eight-week MBI such as MBSR and mindfulness-based cognitive therapy (MBCT), which have typically been used in health research. Both of these eight-week programs cultivate mindfulness, an ancient Buddhist concept described as awareness that emerges through paying attention to the present moment, in an open and nonjudgmental way (Kabat-Zinn, 1990). MBCT was developed from MBSR and includes more information on depression and cognitive therapy-based exercises. The MBSR/MBCT training consists of eight group meetings lasting two and a half hours each, plus one full day during the sixth week of the course. Both trainings incorporate the following formal meditative exercises: body scan, gentle yoga, sitting meditation, and walking meditation (Kabat-Zinn, 1990; Segal, Williams, & Teasdale, 2002).

This review focuses on these two interventions (MBSR; MBCT) because they have been the most widely studied methods to induce mindfulness in clinical and nonclinical samples (Hempel et al., 2014), involve a systematic approach, have a standard protocol, are accessible, and give attention to practical application in daily life. First, we report our review of research on MBI and cognition in older adults. Then, we discuss the potential of MBI to contribute to successful cognitive aging.

Methods

Eligibility criteria

For inclusion in the review, studies were required to have used MBSR or MBCT as intervention. Minor adjustments in session time to accommodate an older population were allowed as long as the training remained eight weeks. Studies in peer-reviewed journals with samples with a mean age of 65 years or older, that used cognitive tasks as outcome measures were included. These eligibility criteria were assessed first at the level of the title, then the abstract, and finally the full article.

Study search and selection

The electronic databases Pubmed, PsychINFO, CINAHL, Web of Science and Cochrane Library, from the first available date until 24 August 2016, were used to search for relevant literature. The search included the following terms (('aging') AND ('MBSR' OR 'MBCT' OR 'mindfulness')). The term 'cognition' was not used for the search to include papers which did not focus on cognition but did report on cognitive test outcomes. In addition to database searches, additional relevant studies were identified from the reference lists of examined articles. Figure 2 represents a flow diagram of the study selection

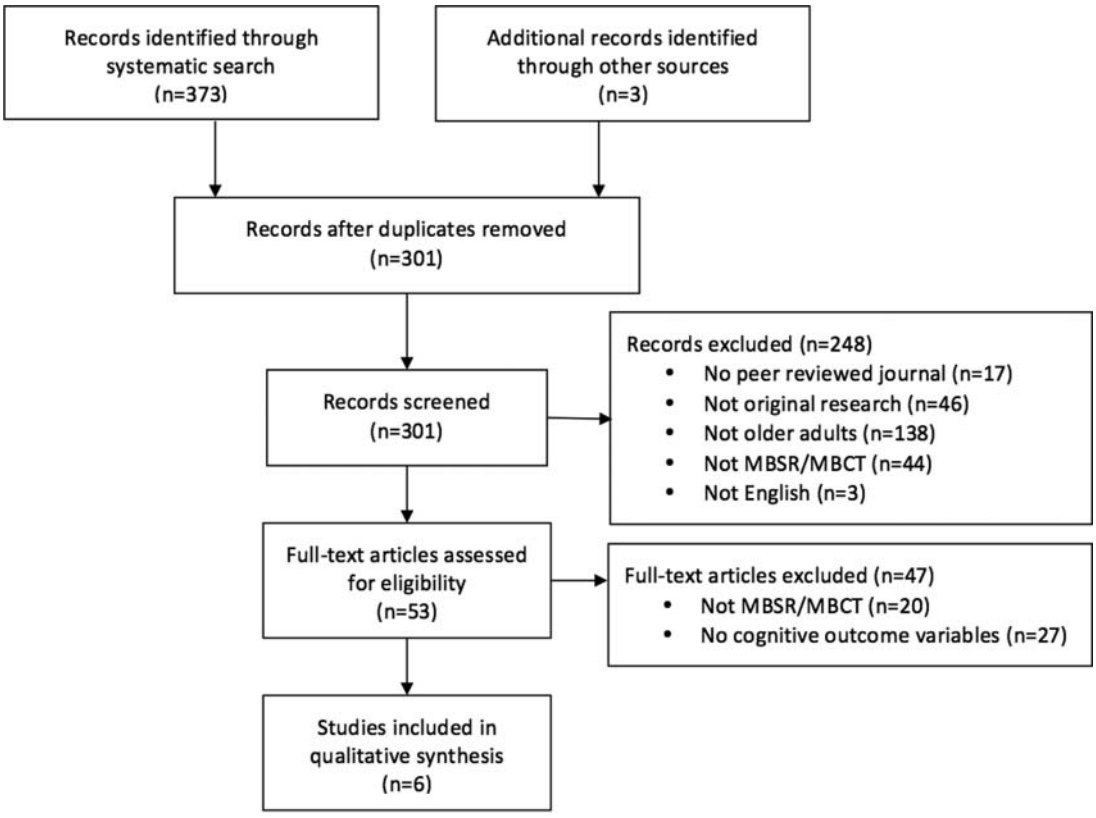


Figure 2. Flow diagram review.

process according to the Consort statement 2010 (www.consort-statement.org).

Data extraction and risk of bias assessment

A summary of the data extraction of the reviewed studies is shown in Table 1. Risk of bias was assessed with the Cochrane Risk of Bias Tool (Table 2; Higgins et al., 2011). Data extraction was conducted by L.B. The risk-of-bias evaluation was conducted by L.B. and M.v.B.; for all ratings, a consensus was reached.

Results

The literature search resulted in a total of 374 records, 370 through the databases (Pubmed 62, PsychINFO 77, CINAHL 17, Web of Science 23, Cochrane Library 191), and three through cross-referencing the examined articles. After screening and full-text assessment, 6 studies were selected for final review. Table 1 presents characteristics of these studies.

Ernst et al. (2008) investigated the feasibility and effects of MBSR on nursing home residents in Germany. Cognitive state was assessed pre- and post-intervention with the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). Other outcome variables were health-related quality of life (Short-Form General Health Survey; SF-12; Ware, Kosinski, & Keller, 1996), depressive symptoms (Geriatric Depression Scale Residential; GDS-12R; Sutcliffe et al., 2000), activities of daily living (Barthel Index; Mahoney & Barthel, 1965), and visual analogue scales of satisfaction with life, physical pain and major complaints. A semi-structured interview was conducted at the end of the course to inquire which elements of the course were helpful and which ones were difficult, and whether the course had been a strain on the participant.

This non-randomized study included fifteen participants (mean age: 80 years) in the MBSR group and seven participants (mean age: 89 years) in the non-intervention group. The intervention group was self-selected: those who wanted to participate could, and those who were only willing to participate for the assessments were the non-intervention group. The MBSR was adjusted by shortening the sessions from 120 min to 90 min, and the physical exercises were simplified to be less strenuous for the elderly participants. Also, the homework assignments were reduced and there was no full day retreat. Nine out of fifteen participants completed the MBSR course.

Change score of outcome measures were compared for the completers of the MBSR group and the non-intervention group. The MBSR group showed significant improvements in health-related quality of life and depressive symptoms. The non-intervention group had more major complaints at baseline than the MBSR group and showed a decrease of major complaints to the level of the MBSR group. The MMSE score did not show a significant difference, however the score stayed the same in the MBSR group (pre- and post-score: 29) and decreased in the non-intervention group (pre: 27; post 24).

As acknowledged by the authors, several limitations were apparent. The groups were self-selected, there were demographic differences between the groups at baseline (age, nursing status and major complaints), no active control group, and attrition was relatively high (40%) in the MBSR group.

Lenze et al. (2014) studied the effects of MBSR on mindfulness, worry, and cognition in older adults with anxiety-related distress and subjective cognitive dysfunction. Thirty-four participants (mean age: 71 years) were assigned to either a standard 8-session MBSR group or to an extended 12-session MBSR group. The retreat day was shortened to one-half day and the intensity of the yoga was reduced. Pre- and post-intervention measurements were carried out. A follow-up at three and six months after completion was conducted to assess continued use of MBSR techniques. A cognitive battery assessed memory and executive function. Verbal memory was measured with the immediate and delayed list and paragraph recall tests of the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, Tierney, Mohr, & Chase, 2010) and California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987) Executive function was measured with the Delis-Kaplan Executive Function Scale (DKEFS) verbal fluency test (Delis, Kaplan, & Kramer, 2001). The RBANS digit span test and DKEFS color-word interference test were administered only for half of the participants and then discontinued. There were no significant differences between the 8-session and 12-session MBSR participants and the scores of both groups together were reported. Participants showed a significant improvement on list delayed recall, paragraph immediate recall, paragraph delayed recall, verbal fluency, and color-word interference. No significant changes were found for list learning and digit span test. Participants showed significant improvements in worry severity (Penn State Worry Questionnaire-Abbreviated; PSWQ-A; Stanley et al., 2003) and mindfulness using the Cognitive Affective Mindfulness Scale-Revised (CAMS-R; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007) but not on the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003). The drop-out rate was low (6%). The majority of participants reported continued use of mindfulness techniques at 3- and 6-month follow-up.

The major limitation of this study is the lack of a control group. There is a strong possibility that the neuropsychological testing with an eight-week interval was biased by practice effects. Moreover, the use of different tests for different groups makes the analysis complex and choosing to drop a test for half the participants but reporting the results for half the group may introduce bias.

Mallya and Fiocco (2015) investigated the effects of MBSR on cognitive functioning and wellbeing in healthy older adults. Participants were randomly assigned to either MBSR ($n = 57$, mean age: 68.8 years) or an active control group ($n = 40$, mean age: 69.7 years). The active control condition consisted of a reading component and relaxation component, and had the same number of sessions and homework as MBSR. Several cognitive domains were assessed. Global cognitive function was assessed using MSSE (Folstein et al., 1975) to compare the groups at baseline. Executive function was assessed with the Trail Making Test (TMT) A and B (Reitan & Wolfson, 1993). Verbal fluency was assessed with Controlled Oral Word Association Task (COWAT; Eslinger, Damasio, & Benton, 1984). Other measurements included Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983), the Geriatric Depression Scale (GDS; Yesavage et al., 1983), Quality of Life Scale (QOLS; Flanagan, 1978), and the Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1965). Controlling for sex, education, and age, data were analyzed separately for the

Table 1. Characteristics of studies.

Author (year)	Design	ITT N (%male)	Completers N (%ITT)	Population	Mean age (SD)	Intervention	Cognitive tests findings	Other findings
Ernst et al. (2008)	Not Random Two groups; MBSR and CON Two time points: Pre- and post-intervention measurements	EXP: 15 (20) CON: 7 (43)	EXP: 9 (60) CON:7 (100)	Nursing home residents	EXP: 80 CON: 89	MBSR Adjustments: –No retreat, –90-minute sessions –Physical exercises simplified –No obligatory time for homework set –Possibility of practice in group twice a week CON: No intervention	No sign. differences between groups: –MMSE	Sig. greater improvement in physical health (SF-12), depression (GDS-12R), and severity of major complaints
Lenze et al. (2014)	Two EXP groups: 8 and 12 weeks (only 8-week results reported here) Two time points: Pre- and post-intervention measurements Pre, midway, post, 3 month and 6 month FU for clinical	EXP(8 weeks): 16 (31) EXP(12 weeks): 18 (22)	EXP(tot): 32 (94)	65+ with worry symptoms and subjective cognitive dysfunction	EXP(8 weeks): 70.9(4.5) EXP(12 weeks): 70.7(4.9)	MBSR (8 and 12 weeks) –Half-day retreat –Reducing intensity of yoga CON: No Control group	No sign. differences pre- and post-intervention: –List learning –Digit span test *Sign. improvement post-intervention: –List delayed recall –Paragraph immediate recall –Paragraph delayed recall –Verbal fluency –Color–word interference **half of participants completed these tests	Worry reduction (PSWQ-A), Increased mindfulness (measured by CAMS-R, but not MAAS), Feasibility (attendance, satisfaction rating)
Mallya and Fiocco (2015)	RCT Two groups: MBSR and CON Pre- and post-intervention measurements	EXP: 57 (23) CON: 40 (30)	EXP: 53 (91) CON: 33 (70)	65+ healthy	EXP: 68.8(4.6) CON: 69.7(4.9)	MBSR Adjustments: –Half-day retreat –30 minutes instead of 40 minutes daily homework CON: Active control (reading and relaxation)	No sign. differences pre/post between groups: –MMSE –CVLT-LDFR –TMT A –TMT B –COWAT-FAS –COWAT-Animal	MAAS (CON>EXP) PSS (*ns*) Depression GDS (*ns*) QoL (EXP>CON) RSES (*ns*)
Moynihan et al. (2013)	RCT Two groups: MBSR and CON Four time points: Pre- and post-intervention, 3 weeks later, 21 weeks later	EXP: 108 (38) CON:111 (38)	EXP: 105 (97) CON:103 (93)	Older adults	EXP: 73.3(6.7) CON: 73.6(6.7)	MBSR Adjustments: –120-minute sessions –Adjusted yoga CON: Waiting List	–Trail B/A Ratio: EXP sign. better than CON at post-intervention but not at FU1 or FU2	CES-D-R (*ns*) PSS (*ns*) MAAS (EXP>CON) Greater alpha asymmetry EXP Antibody response (EXP higher at FU1, but lower at FU2)
O'Connor et al. (2014)	Not randomized Two groups: MBCT and waitlist control Three time points: Pre- and post-intervention, and 5 month FU	EXP: 18 (28) CON: 18 (33)	EXP: 12 (67) CON: 18 (100)	Elderly bereaved people with loss-related distress	EXP: 76.7(4.5) CON: 77.0(4.1)	MBCT Adjustments: –120-minute sessions –Psychoeduction on general negative affect instead of depressive symptoms –Booster session at 3 and 6 months -post-intervention CON: Waiting List	Letter number sequencing (trend EXP improved)	BDI (EXP improved compared to CON) HTQ (*ns*) ICG-R (*ns*)
Smart et al. (2016)[a]	RCT Two Groups: MBSR and psychoeducation CON	SCD: 23 (61) CON: 15 (27)	SCD: 22 (96) CON: 15 (93)	Older adults with and without SCD	SCD: 70.0 (3.45) CON: 69.60 (3.58)	MBSR Adjustments: 120-minute sessions CON: Psychoeducationon cognitive aging	No sign. differences between groups: –Go/Nogo RT –Go/Nogo accuracy –EXP but not CON reduced: –Go/Nogo RT IIV	P3 ERP (EXP>CON) CCI (ns) FFMQ-A (ns) GDS (ns) Memory self-efficacy PVBC (EXP>CON)

BDI: Beck Depression Inventory; CAMS-R: Cognitive Affective Mindfulness Scale-Revised; CCI: Cognitive Complaints Index comprised of complaints items from the GDS, Memory Complaints Questionnaire and Metamemory in Adulthood Questionnaire; CON: Control Group; COWAT: Controlled Oral Word Association Task; CVLT-LDFR: California Verbal Learning Test- Long Delay Free Recall; EXP: Experimental Group; FFMQ-A: Mindful Attention composite from Five Facet Mindfulness Questionnaire subscales Observe, Describe, and Act with Awareness; FU: Follow-up; GDS: Geriatric Depression Scale; GDS-12R: Geriatric Depression Scale Residential; HTQ: Harvard Trauma Questionnaire; ICG: Inventory of Complicated Grief –Revised; ITT: Intention to treat; MAAS: Mindful Attention Awareness Scale; MBCT: Mindfulness-Based Cognitive Therapy; MBSR: Mindfulness-Based Stress Reduction; MCI: Mild Cognitive Impairment; MMSE: Mini-Mental State Examination; ns: no significant difference between groups; PSWQ-A: Penn State Worry Questionnaire-Abbreviated; PVBC: Percent Brain Volume Change; QOLS: Quality of Life Scale; RCT: randomized controlled trial; RSES: Rosenberg Self-Esteem Scale; SCD: Subjective Cognitive Decline; SF-12: Short-Form General Health Survey; TMT: Trail Making Test.

[a] This study compared healthy controls and SCD in both MBSR and CON. This table shows results are for comparison MBSR with CON only.

Table 2. Risk of bias summary.

Author (year)	Selection bias Random sequence generation	Performance bias Allocation concealment	Detection bias Blinding of participants and personnel	Attrition bias Treatment fidelity	Reporting bias Blinding of outcome assessment	Incomplete outcome data	Selective reporting
Ernst et al. (2008)	N/A	N/A	?	?	?	−	?
Lenze et al. (2014)	N/A	N/A	−	+	?	+	−
Mallya and Fiocco (2015)	+	+	+	+	+	+	?
Moynihan et al. (2013)	+	?	?	+	?	+	−
O'Connor et al. (2014)	−	−	−	?	?	+	?
Smart et al. (2016)	?	+	+	?	?	+	?

Note: ?Unknown risk; +Low risk; −High risk.

intention-to-treat (ITT) participants and the participants who completed the training (i.e. per protocol treatment (PPT)). The completion rate was marginally higher (but not significantly different) for the MBSR group (91%) than the active control group (70%). No significant differences were found on the cognitive scores in either the ITT or PTT analyses, although there was a trend for MBSR completers to improve performance on the delayed recall compared to active control. Also, no changes on the measurements of wellbeing were found. The authors suggested that these null-findings could be attributed to ceiling effects, given that the participants were healthy, high-functioning older adults. Perhaps there was no room for improvement in this sample, and the beneficial effects of MBSR only apply to those with high levels of distress.

This study is one of two RCTs in the review with an active control group. The active control group was to control for nonspecific effects. However, the progressive muscle relaxation used in the control group requires attention and awareness, and may have some overlap with the MBSR program. Another limitation of the study is omission of an additional wait list control group for better comparison with previous studies. Despite these minor limitations, this study was the first well-designed and controlled study in healthy older adults.

Moynihan et al. (2013) studied the effects of MBSR on executive function, frontal alpha asymmetry and immune function in older adults. Other measurements included mindfulness (MAAS; Brown & Ryan, 2003), perceived stress (PSS; Cohen et al., 1983) and depression, assessed with the Center for the Epidemiologic Studies Depression Scale-Revised (CES-D-R; Lewinsohn, Seeley, Roberts, & Allen, 1997). Executive function was assessed using the TMT B/A ratio. Participants ($n = 201$) were randomized into an MBSR (mean age: 73.3 years) or waitlist control group (mean age: 73.6 years). The MBSR participants showed improved executive function with a significantly lower TMT B/A ratio compared to the control group at post-intervention but not at the 3-week or 24-week follow-up. No significant differences in trails A or B were found at any of the time points. The MBSR group had higher MAAS scores after the intervention ($p = 0.023$) and at follow-up 24 weeks later ($p = 0.006$). The immune response (measured by antibody response after antigen challenge) of the MBSR participants was greater than the control group immediately after the intervention. Contrary to the hypothesis, the MBSR group's immune response was lower 24 weeks after intervention.

This was the first RCT with a large sample of older adults, but it also has some limitations. The study did not include an active control group and the control group differed from the MBSR group at baseline; scoring lower on perceived self-control and depression scores, and higher on mindfulness.

O'Connor, Piet, and Hougaard (2014) investigated the effects of MBCT on depressive symptoms (Beck Depression Inventory; Beck, Steer, & Carbin, 1988), posttraumatic stress (PTSS; measured with Harvard Trauma Questionnaire – Part IV; Mollica et al., 1992), complicated grief (Inventory of Complication Grief – Revised; Prigerson et al., 1995) and working memory (letter-number sequencing; Wechsler, 1997) in elderly bereaved people with long-term bereavement-related distress. These outcome measures were assessed pre- and post-intervention and five months after intervention. This non-randomized pilot study enrolled 18 participants in the MBCT group (mean age: 76.7 years) and 18 participants in a wait-list control group (mean age: 77.0 years). Twelve participants (67%) of the MBCT group completed the intervention, no significant differences were found between completers and intention-to-treat (ITT). A significant increase in working memory was found post-intervention for the MBCT group, but not the waitlist group. This difference disappeared at five-month follow-up. Furthermore, depressive symptoms decreased for the MBCT group, and not for the wait-list control group, at the five-month follow-up, but not immediately after the intervention. No significant differences were found for PTSS or complicated grief scores.

This pilot study shows promising results in terms of improved working memory, but without lasting effects after the intervention. The authors note that most participants discontinued daily formal mindfulness practice, which may be the reason for the lack of persistence. One of the limitations of this study is that it is non-randomized due to practical reasons: the MBCT group consisted of persons living close to the place where the intervention took place.

Smart, Segalowitz, Mulligan, Koudys, and Gawryluk (2016) investigated the feasibility and effects of MBSR on cognitive electrophysiology (P3 event-related potential (P3 ERP) component), attention, structural magnetic resonance imaging (MRI), and psychological functioning on older adults with and without subjective cognitive decline (SCD). This randomized controlled study included 15 older adults with SCD (mean age: 69.6) and 23 without SCD (mean age: 70.0). Two participants (one of each group) failed to complete the intervention and post-testing due to health reasons, bringing the total to 36 participants. Both groups were randomized to either 8-week MBSR or a 5-week psychoeduction program on cognitive aging. The assessment took place within four weeks before intervention and within two weeks after intervention. EEG was taken during the Go/NoGo task. The behavioral measures from this task (reaction time, accuracy and reaction time intra-individual variability (RT IIV) were measured. RT IIV was used to assess attention regulation and been proposed as an indicator of future pathological cognitive decline (Bielak, Hultsch, Strauss, Macdonald, & Hunter, 2010). The self-report

measures included an index of cognitive complaints from combined items of GDS, Memory Complaints Questionnaire (Crook, Feher, & Larrabee, 1992), and items from the Metamemory in Adulthood Questionnaire (Dixon, Hultsch, & Hertzog, 1988). Moreover, depression was assessed using the items on the GDS that were not cognitive complaints. Memory self-efficacy was assessed using the Memory Self-Efficacy Questionnaire (Berry, West, & Dennehey, 1989). Attention regulation was assessed with the three subscales from the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2008), namely Describe, Observe and Act Aware. The structural MRI was used to measure percent brain volume change pre-/post-intervention. This study compared both the interventions (MBSR or psychoeducation) and the groups (SCD or healthy control). Participants showed a reduction in cognitive complaints and depression, regardless of the intervention type. Mindfulness attention did not change after either intervention. Memory self-efficacy increased for SCD and decreased for the healthy controls after both interventions. Participants with SCD receiving MBSR, but not PE, showed increase P3 amplitude post-intervention, approximating scores of healthy controls. The behavioral results of the Go/NoGo task showed that there was no effect on RT, and an increase in accuracy for all participants. Importantly, all MBSR participants showed a reduction in Go/Nogo RT IIV, indicating an increased ability in moment-to-moment regulation of attention. The authors suggest that being able to better regulate attention might compensate for memory difficulties in older adults with cognitive decline. The structural MRI with a subset (PE $n = 6$, MBSR $n = 8$) showed increase in brain volume in the MBSR group.

This pilot study is the only other RCT discussed in this review with an active control group (PE). It demonstrated the feasibility of MBSR with older adults with and without SCD. Attention regulation was improved in all MBSR participants. This well-designed study, including a rigorous screening process, can serve as an example for future studies with the addition of a follow-up assessment to see whether the observed changes remain stable in the long term.

Discussion

Summary

We reviewed six studies investigating the effects of MBI on cognition in older adults. The studies reported a variety of neuropsychological tests to measure global cognitive function, executive function and memory.

Tests that were used by more than one study were the MMSE (Ernst et al., 2008; Mallya & Fiocco, 2015), verbal fluency (Lenze et al., 2014; Mallya & Fiocco, 2015), and the TMT (Mallya & Fiocco, 2015; Moynihan et al., 2013; Paller et al., 2014). No effects on the MMSE were found. Lenze et al. (2014) reported improvements post-intervention on verbal fluency; however, there was no control group. The RCT by Mallya and Fiocco (2015) did not report significant findings on verbal fluency. They also did not find significant differences on the TMT; however, Moynihan et al. (2013) reported significant changes on the TMT (only when using the B/A ratio) at post-intervention compared to control. This difference disappeared at follow-up after 3 and 21 weeks (Moynihan et al., 2013). Other findings include a trend of post-intervention improvement compared to controls on working memory (O'Connor et al., 2014) and improved regulation of attention (Smart et al., 2016). Most neuropsychological tests did not show any differences between intervention and control groups. Although Lenze et al. (2014) reported significant improvement on several tests, this study did not include a control group.

Three of the six reviewed studies were RCTs (Mallya & Fiocco, 2015; Moynihan et al., 2013; Smart et al., 2016). Most of the studies were conducted as pilot projects and can be interpreted as evidence of feasibility of MBI interventions in older adults. It was demonstrated that no major adjustments to the standard protocol of MBSR/MBCT are necessary. Also, there is no support for the notion that increasing the length of the intervention would be an improvement (Lenze et al., 2014).

The study with the highest quality showed no differences between MBSR and the active control group on several cognitive measures (Mallya & Fiocco, 2015). However, the sample consisted of high functioning adults and therefore ceiling effects cannot be excluded. One of the strengths of this study was the inclusion of an active control group, but some of the exercises had overlap with the mindfulness exercises (e.g. relaxation). It may be productive for future studies to compare MBI with a group-based psychoeducation intervention such as was used by Smart et al. (2016). The Mallya and Fiocco study (2015) can serve as an example of how future studies may be conducted, extending the sample to populations of older adults with cognitive complaints or depressive symptoms. For example, a meta-analysis showed significant effects of MBCT in individuals with elevated levels of depression and anxiety, but smaller effects in non-clinical populations (Hofmann, Sawyer, Witt, & Oh, 2010). Of course, it remains to be examined if this holds for cognitive outcomes in older adults. Regarding cognitive complaints, Smart et al. (2016) showed in a well-designed pilot study that older adults with subjective cognitive decline reported less cognitive complaints and increased memory self-efficacy following MBSR. Future studies that incorporate follow-up and larger samples will show whether these effects are robust.

Limitations

Several problems with these studies were identified. Most studies had a high risk of bias ratings. Only one study (Mallya & Fiocco, 2015) had more 'low' risk bias ratings than 'unclear' or 'high' risk (Table 2). Different neuropsychological tests were used, and most did not include an elaborate battery of tests or used measures that were not very sensitive (e.g. MMSE), making it difficult to draw conclusions. Lack of statistical power is another problem. According to a review on MBSR trials, 33 participants per group are required in a two group design to achieve an 80% chance of detecting medium-to-large treatment effects (Baer, 2003). Only two of the six studies in this review have a sample size that can be considered adequate. Moreover, only two studies used an active control group. The studies included different groups of older adults, ranging from healthy individuals to people with cognitive complaints or bereaved individuals with loss-related stress.

Conclusions

This review highlights the need for more rigorous studies that examine the effect of a standard 8-week MBI on cognition in older adults, because current evidence is not sufficient to

draw a conclusion. Feasibility and acceptability have been demonstrated, and the shift has to be made toward well-designed studies to advance knowledge in this area. The use of a standardized intervention format, active control group, large sample size and extensive neuropsychological test battery is recommended.

It is recommended that future studies on cognitive functioning also include measurements on daily life functioning. Improved performance on a neuropsychological test might not always be indicative of improved functioning in daily life. That is, other studies on cognitive training with older adults have shown small effects, and the problem is that even though individuals may score higher on a test, this may not impact daily life functioning in any way. The strength of the MBI may not necessarily lie in improving objective cognitive performance but in how people relate to their cognitive problems, improving wellbeing and helping individuals make better life style choices. There is growing evidence of improved wellbeing in elderly participating in MBI, such as substantial reductions of emotional stress in older adults with depression and anxiety after MBSR (Young & Baime, 2010). Future research could focus on the mechanisms of this process to get a deeper understanding of why and for whom this intervention works. For example, the experience sampling method (Myin-Germeys et al., 2009) may be used to investigate the effect of MBI on stress reactivity.

Regular meditation over a prolonged period of time may have a protective effect on cognitive aging (Gard et al., 2014; Luders, 2014). Prevention in the preclinical stage may be the most effective way to decrease the incidence of age-related cognitive decline. MBI could work at two different stages of life. The first would begin at an earlier life stage as prevention, possibly slowing down age-related cognitive decline by brain structure and life style. The second approach would incorporate MBI at a later life stage; to reduce burden of worries, depression and anxiety symptoms. Moreover, MBI has the advantage of being inexpensive, and easy to teach and perform. However, in order to substantiate such supposed benefits of MBI, more well-designed studies with standardized protocols are required.

Disclosure statement

All authors declare that they have no conflict of interest.

Funding

This work was supported by LB's personal research grant by Netherlands Organization for Scientific Research (NWO) [grant number 022.005.019].

References

Baer, R.A. (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology: Science and Practice, 10*(2), 125–143. http://doi.org/10.1093/clipsy/bpg015

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

Beck, A.T., Steer, R.A., & Carbin, M.G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review, 8*(1), 77–100. http://doi.org/10.1016/0272-7358(88)90050-5

Berry, J.M., West, R.L., & Dennehey, D.M. (1989). Reliability and validity of the memory self-efficacy questionnaire. *Developmental Psychology, 25*(5), 701–713. http://doi.org/10.1037/0012-1649.25.5.701

Bielak, A.A.M., Hultsch, D.F., Strauss, E., Macdonald, S.W.S., & Hunter, M.A. (2010). Intraindividual variability in reaction time predicts cognitive outcomes 5 years later. *Neuropsychology, 24*(6), 731–741. http://doi.org/10.1037/a0019802

Blackburn, E.H., & Epel, E.S. (2012). Telomeres and adversity: Too toxic to ignore. *Nature, 490*(7419), 169–71. http://doi.org/10.1038/490169a

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), 822–848. http://doi.org/10.1037/0022-3514.84.4.822

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review, 31*(3), 449–464. http://doi.org/10.1016/j.cpr.2010.11.003

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*(4), 385–396. http://doi.org/10.2307/2136404

Creswell, J.D., Irwin, M.R., Burklund, L.J., Lieberman, M.D., Arevalo, J.M.G., Ma, J., … 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, Behavior, and Immunity, 26*(7), 1095–101. http://doi.org/10.1016/j.bbi.2012.07.006

Crook, T.H., Feher, E.P., & Larrabee, G.J. (1992). Assessment of memory complaint in age-associated memory impairment: The MAC-Q. *International Psychogeriatrics, 4*(2), 165–176. http://doi.org/10.1017/S1041610292000991

de Frias, C.M., & Whyne, E. (2015). Stress on health-related quality of life in older adults: The protective nature of mindfulness. *Aging & Mental Health, 19*(3), 201–206. http://doi.org/10.1080/13607863.2014.924090

Delis, D.C., Kramer, J.H., & Kaplan, E.,O.B.A. (1987). *California verbal learning test: Adult version*. San Antonio, TX: The Psychological Corporation.

Delis, D., Kaplan, E., & Kramer, J. (2001). Delis-Kaplan executive function system (D-KEFS). *Canadian Journal of School Psychology, 20*(1–2), 117–128. http://doi.org/10.1177/0829573506295469

Dixon, R., Hultsch, D., & Hertzog, C. (1988). The metamemory in adulthood (MIA) questionnaire. *Psychopharmacology Bulletin, 24*, 671–688.

Epel, E., Daubenmier, J., Moskowitz, J.T., Folkman, S., & Blackburn, E. (2009). Can meditation slow rate of cellular aging? Cognitive stress, mindfulness, and telomeres. *Annals of the New York Academy of Sciences, 1172*(1), 34–53.

Ernst, S., Welke, J., Heintze, C., Gabriel, R., Zöllner, A., Kiehne, S., … Esch, T. (2008). Effects of mindfulness-based stress reduction on quality of life in nursing home residents: A feasibility study. *Forschende Komplementärmedizin (2006), 15*(2), 74–81. http://doi.org/10.1159/000121479

Eslinger, P., Damasio, A., & Benton, A. (1984). *The Iowa screening battery for mental decline*. Iowa City, IA: University of Iowa.

Feldman, G., Hayes, A., Kumar, S., Greeson, J., & Laurenceau, J.P. (2007). Mindfulness and emotion regulation: The development and initial validation of the Cognitive and Affective Mindfulness Scale-Revised (CAMS-R). *Journal of Psychopathology and Behavioral Assessment, 29*(3), 177–190. http://doi.org/10.1007/s10862-006-9035-8

Fjorback, L.O., Arendt, M., Ornbøl, E., Fink, P., & Walach, H. (2011). Mindfulness-based stress reduction and mindfulness-based cognitive therapy: A systematic review of randomized controlled trials. *Acta Psychiatrica Scandinavica, 124*(2), 102–19. http://doi.org/10.1111/j.1600-0447.2011.01704.x

Flanagan, J.C. (1978). A research approach to improving our quality of life. *American Psychologist, 33*(2), 138–147. http://doi.org/10.1037/0003-066X.33.2.138

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. *Journal of Psychiatric Research, 12*(3), 189–198.

Foulk, M.A., Ingersoll-Dayton, B., Kavanagh, J., Robinson, E., & Kales, H.C. (2014). Mindfulness-based cognitive therapy with older adults: An exploratory study. *Journal of Gerontological Social Work, 57*(5), 498–520. http://doi.org/10.1080/01634372.2013.869787

Gallegos, A.M., Hoerger, M., Talbot, N.L., Moynihan, J.A., & Duberstein, P.R. (2013). Emotional benefits of mindfulness-based stress reduction in older adults: The moderating roles of age and depressive symptom severity. *Aging & Mental Health, 17*(7), 823–829. http://doi.org/10.1080/13607863.2013.799118

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. http://doi.org/10.1111/nyas.12348

Gard, T., Taquet, M., Dixit, R., Hölzel, B.K., de Montjoye, Y.-A., Brach, N., … Lazar, S.W. (2014). Fluid intelligence and brain functional organization in aging yoga and meditation practitioners. *Frontiers in Aging Neuroscience, 6*(April), 1–12. http://doi.org/10.3389/fnagi.2014.00076

Hempel, S., Taylor, S.L., Marshall, N.J., Miake-Lye, I.M., Beroes, J.M., Shanman, R., … Shekelle, P.G. (2014). *Evidence map of mindfulness*. Washington, DC: Department of Veterans Affairs.

Higgins, J.P.T., Altman, D.G., Gøtzsche, P.C., Jüni, P., Moher, D., Oxman, A.D. , … Sterne, J.A.C. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ (Clinical Research Ed.), 343*(Oct 18_2), d5928. http://doi.org/10.1136/bmj.d5928

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), 169–83. http://doi.org/10.1037/a0018555

Kabat-Zinn, J. (1990). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. New York, NY: Delacorte. http://doi.org/10.1037/032287

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), 519–28. http://doi.org/10.1016/j.jpsychores.2015.03.009

Kurth, F., Cherbuin, N., & Luders, E. (2015). Reduced age-related degeneration of the hippocampal subiculum in long-term meditators. *Psychiatry Research, 232*(3), 214–8. http://doi.org/10.1016/j.pscychresns.2015.03.008

Lenze, E.J., Hickman, S., Hershey, T., Wendleton, L., Ly, K., Dixon, D., … 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. http://doi.org/10.1002/gps.4086

Lewinsohn, P.M., Seeley, J.R., Roberts, R.E., & Allen, N.B. (1997). Center for Epidemiologic Studies Depression Scale (CES-D) as a screening instrument for depression among community-residing older adults. *Psychology and Aging, 12*(2), 277–87. http://doi.org/10.1037/0882-7974.12.2.277

Luders, E. (2014). Exploring age-related brain degeneration in meditation practitioners. *Annals of the New York Academy of Sciences, 1307*(1), 82–88. http://doi.org/10.1111/nyas.12217

Mahoney, F.I., & Barthel, D.W. (1965). Functional evaluation: The Barthel index. *Maryland State Medical Journal, 14*, 61–5.

Mallya, S., & Fiocco, A.J. (2015). Effects of mindfulness training on cognition and well-being in healthy older adults. *Mindfulness, 7*(2), 453–465. http://doi.org/10.1007/s12671-015-0468-6

Marciniak, R., Sheardova, K., Cermáková, P., Hudeček, D., Sumec, R., & Hort, J. (2014). Effect of meditation on cognitive functions in context of aging and neurodegenerative diseases. *Frontiers in Behavioral Neuroscience, 8*, 17. http://doi.org/10.3389/fnbeh.2014.00017

Mollica, R.F., Caspi-Yavin, Y., Bollini, P., Truong, T., Tor, S., & Lavelle, J. (1992). The Harvard trauma questionnaire: Validating a cross-cultural instrument for measuring torture, trauma, and posttraumatic stress disorder in Indochinese refugees. *The Journal of Nervous and Mental Disease, 180*(2), 111–116. http://doi.org/10.1097/00005053-199202000-00008

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. http://doi.org/10.1159/000350949

Myin-Germeys, I., Oorschot, M., Collip, D., Lataster, J., Delespaul, P., & van Os, J. (2009). Experience sampling research in psychopathology: Opening the black box of daily life. *Psychological Medicine, 39*(9), 1533–1547.

O'Connor, M., Piet, J., & Hougaard, E. (2014). The effects of mindfulness-based cognitive therapy on depressive symptoms in elderly bereaved people with loss-related distress: A controlled pilot study. *Mindfulness, 5*, 400–409. http://doi.org/10.1007/s12671-013-0194-x

Paller, K.A., Creery, J.D., Florczak, S.M., Weintraub, S., Mesulam, M.-M., Reber, P.J., … Maslar, M. (2014). Benefits of mindfulness training for patients with progressive cognitive decline and their caregivers. *American Journal of Alzheimer's Disease and Other Dementias*, *30*(3), 257–267.

Palta, P., Page, G., Piferi, R.L., Gill, J.M., Hayat, M.J., Connolly, A.B., … Szanton, S.L. (2012). Evaluation of a mindfulness-based intervention program to decrease blood pressure in low-income African-American older adults. Journal of Urban Health, *89*(2), 308–316. http://doi.org/10.1007/s11524-011-9654-6

Prigerson, H.G., Maciejewski, P.K., Reynolds, C.F., Bierhals, A.J., Newsom, J. T., Fasiczka, A., … Miller, M. (1995). Inventory of complicated grief: A scale to measure maladaptive symptoms of loss. *Psychiatry Research, 59*(1–2), 65–79. http://doi.org/10.1016/0165-1781(95)02757-2

Randolph, C., Tierney, M.C., Mohr, E., & Chase, T.N. (2010). The repeatable battery for the assessment of neuropsychological status (RBANS): Preliminary clinical validity. *Journal of Clinical and Experimental Neuropsychology, 20*(3), 310–319.

Reitan, R., & Wolfson, D. (1993). *The halstead-reitan neuropsychological test battery: Theory and clinical applications*. Tucson, AZ: Neuropsychology Press.

Rosenberg, M. (1965). *Society and the adolescent self-image*. Princeton, NJ: Princeton University Press.

Schutte, N.S., & Malouff, J.M. (2014). A meta-analytic review of the effects of mindfulness meditation on telomerase activity. *Psychoneuroendocrinology, 42*, 45–8. http://doi.org/10.1016/j.psyneuen.2013.12.017

Segal, Z.V., Williams, J.M.G., & Teasdale, J.D. (2002). *Mindfulness-based cognitive therapy for depression: A new approach to preventing relapse*. New York, NY: Guilford.

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*(2), 757–774. http://doi.org/10.3233/JAD-150992

Splevins, K., Smith, A., & Simpson, J. (2009). Do improvements in emotional distress correlate with becoming more mindful? A study of older adults. *Aging & Mental Health, 13*(3), 328–35. http://doi.org/10.1080/13607860802459807

Stanley, M.A., Diefenbach, G.J., Hopko, D.R., Novy, D., Kunik, M.E., Wilson, N., … Wagener, P. (2003). The nature of generalized anxiety in older primary care patients: Preliminary findings. *Journal of Psychopathology and Behavioral Assessment, 25*(4), 273–280. http://doi.org/10.1023/A:1025903214019

Sutcliffe, C., Cordingley, L., Burns, A., Mozley, C.G., Bagley, H., Huxley, P., … Challis, D. (2000). A new version of the geriatric depression scale for nursing and residential home populations: The geriatric depression scale (residential) (GDS-12R). *International Psychogeriatrics / IPA, 12*(2), 173–81.

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

Ware, J., Kosinski, M., & Keller, S.D. (1996). A 12-item short-form health survey: Construction of scales and preliminary tests of reliability and validity. *Medical Care, 34*(3), 220–33.

Wechsler, D. (1997). *WAIS−III administration and scoring manual*. San Antonio, TX: The Psychological Corporation.

Wells, R.E., Yeh, G.Y., Kerr, C.E., Wolkin, J., Davis, R.B., Tan, Y., … Kong, J. (2013). Meditation's impact on default mode network and hippocampus in mild cognitive impairment: A pilot study. *Neuroscience Letters, 556*, 15–19. http://doi.org/10.1016/j.neulet.2013.10.001

Yesavage, J., Brink, T.L., Rose, T.L., Lum, O., Huang, V., Adey, M., … Leirer, V. O. (1983). Development and validation of a geriatric depression screening scale: A preliminary report. *Journal of Psychiatric Research, 17*(1), 37–49. http://doi.org/10.1016/0022-3956(82)90033-4

Young, L.A., & Baime, M.J. (2010). Mindfulness-based stress reduction: Effect on emotional distress in older adults. *Complementary Health Practice Review, 15*(2), 59–64. http://doi.org/10.1177/1533210110387687