The impact of meditation on healthy ageing – the current state of knowledge and a roadmap to future directions

Olga Klimecki[*a], Natalie L. Marchant[b], Antoine Lutz[c], Géraldine Poisnel[d], Gaël Chételat[d], Fabienne Collette[e]

Author Affiliations (and e-mails)

[a] Swiss Center for Affective Sciences, Department of Medicine, University of Geneva, Geneva, Switzerland.

[b] Division of Psychiatry, University College London, London, United Kingdom; n.marchant@ucl.ac.uk

[c] Lyon Neuroscience Research Center INSERM U1028, CNRS UMR5292, Lyon University, Lyon, France; antoine.lutz@inserm.fr

[d] Université Normandie, Inserm, Université de Caen-Normandie, Inserm UMR-S U1237, GIP Cyceron, Caen, France. poisnel@cyceron.fr; chételat@cyceron.fr

[e] GIGA-CRC In Vivo Imaging and Psychology and Cognitive Neuroscience Research Unit, Liège University, Belgium; Belgian national fund for scientific research, F.R.S.-FNRS. f.collette@uliege.be

[*]Corresponding author: Olga Klimecki; Swiss Center for Affective Sciences, University of Geneva, Campus Biotech, Chemin des Mines 9, 1202 Geneva. Telephone: +41 22 37 90 913 Fax: +41 22 379 06 10; E-Mail: olga.klimecki@unige.ch

Abstract (111 words)

There is increasing evidence that meditation-based training promotes healthy ageing across many dimensions. This review summarizes the existing knowledge on the effects of meditation training on healthy ageing in the domains of emotions, cognition (with a special emphasis on attentional processes), and the preservation of related brain structures. Although evidence so far is promising, more rigorous randomized controlled studies with active control groups and long-term follow-up in older people are needed. We outline how these challenges can be addressed in future studies using the example of an ongoing project, Medit-Ageing (public name: Silver Santé Study), including two independent randomized controlled trials (RCT) as well as one cross-sectional study with meditation experts.

Keywords: dementia; emotion; attention; cognition; compassion; anxiety; depression; stress; Medit-Ageing; allostatic load

Highlights

- meditation practice may promote healthy ageing and delay the onset of dementia
- expert meditators have more preserved brain structures than age-matched controls
- meditation practice improves cognitive functions, including attention
- meditation reduces anxiety, depression, and stress and promotes positive emotions
- more rigorous studies are needed to substantiate these effects in elderly

With increases in life expectancy worldwide [1], promoting healthy ageing becomes increasingly important. Healthy ageing is not only crucial for maintaining the quality of life in older individuals, but also to enable elderly people to thrive in their role in society, be it in their profession or in their private lives (e.g., as grandparents or friends). In recent years, it has been recognized that meditation-based training offers a promising strategy to promote healthy ageing [2]. Indeed, the effects of meditation training are increasingly studied in young and middle-age adults. However, there is still relatively little research on the impact of meditation training on older adults. This review summarizes evidence on how meditation can contribute to healthy ageing and optimize cognitive and emotional processes impacted by ageing. It ends by outlining future research avenues.

In order to investigate the effects of meditation training on cognition and emotion, usually two types of studies are employed: i) cross-sectional studies comparing experienced meditators with non-meditators and ii) longitudinal studies comparing meditation training to a control group. The most prevalent form of training employed in longitudinal studies is mindfulness meditation. Mindfulness meditation consists of cultivating a vigilant awareness of one's own thoughts, actions, emotions and motivations. In mindfulness meditation, one learns to intentionally attend to internal or external experiences in the present moment, without making any value judgment [3].

Meditation training may delay dementia and promote healthy ageing

Dementia currently affects 50 million people worldwide [4], and is broadly defined by brain atrophy, significant decline in cognitive and/or behavioural functioning, and loss of ability to live independently [5]. In so far as meditation

practice has been shown to improve cognition, wellbeing and health in older age, it could potentially contribute to delay onset of dementia.

Preliminary evidence suggests that meditation training preserves brain structure, glucose metabolism, and brain connectivity in older adults

Cross-sectional evidence from several studies in expert meditators suggests that meditation may preserve brain structure and glucose metabolism. First studies in this domain showed a preservation of cortical thickness and grey matter volumes in young and middle-age meditation experts [6], as well as reduced age-related atrophy of brain grey matter volume in meditators compared to non-meditators, particularly in hippocampus, frontal and temporal brain regions [7,8]. In a recent study, grey matter brain volumes and glucose metabolism from 6 older-adult expert meditators were compared with 67 age-matched controls [9]. As summarized in **Figure 1**, meditation experts had more preserved grey matter volume and/or more glucose metabolism at rest than non-meditators in brain regions sensitive to ageing, including ventromedial prefrontal cortex, anterior cingulate cortex, bilateral temporo-parietal junction, insula and posterior cingulate cortex [9]. In another study a machine learning algorithm trained to identify anatomical correlates of age in the brain revealed that structural brain characteristics of expert meditators appeared 7.5 years younger than those of age-matched controls [10]. Moreover, long-term expert meditators had larger fractional anisotropy than controls, indicating more numerous, dense and fast fiber tract connections [11]. As cross-sectional studies with expert meditators can be biased by self-selection, it is important to corroborate these findings in longitudinal studies. One longitudinal study assessing the impact of eight weeks of mindfulness based meditation on brain connectivity found that meditation versus relaxation

training decreased network connectivity within default mode in older adults, which may indicate more efficient cognitive processes [12]. Overall, these preliminary neuroimaging studies suggest that meditation practice could help to preserve grey matter brain structures, brain glucose metabolism and brain connectivity in older age. However, more research is needed to test in how far such effects also extend to older novice meditators.

INSERT FIGURE 1 ABOUT HERE

A beneficial effect of meditation training on cognition and attention

Cognitive decline is one of the greatest concerns of older adults. Cognitive domains primarily affected by ageing are memory, executive functions, and attention [13]. Decline in these domains may also indicate an increased risk of developing dementia [14]. Cross-sectional studies that have examined relationships between long-term meditation and standardized measures of cognition in older adults are scarce. However, emerging evidence suggests that long-term meditators have higher levels of attention, executive function, and fluid intelligence (reasoning and problem solving) compared with non-meditators [15-17]. Whether long-term meditation also improves episodic memory in older adults has – to our knowledge – not been tested yet.

Pertaining to short-term training, reviews of age-related effects from short-term meditation training on cognitive abilities (only 6 of which were randomized control

trials) also reported improvements in memory, attention and executive function [18,19]. It is not yet resolved, however, to what degree meditation training is superior to active control groups. Whereas some studies found no differential benefit of mindfulness interventions when compared to active control groups or comparison conditions on cognition outcomes [20-22], other studies suggest that meditation training can be superior to other interventions. A positive effect of mindfulness-intervention by comparison to active control conditions was thus observed in two studies including participants with i) clinical anxiety and/or depression and cognitive concerns (all indicators of increased dementia risk) [23] and ii) people with dementia [24]. Interestingly, improvements in memory and executive function were associated with a reduction in worry in the first study and to preserved global cognitive function in the second one. Although these results suggest that meditation may be particularly effective at preserving cognition against age-related decline rather than 'improving' cognition per se, more rigorous randomized-control studies with long-term interventions, active control conditions and follow-ups are needed, especially in the population of older adults with cognitive impairments or at heightened risk of dementia.

Attentional functioning seems particularly susceptible to meditation practice. Indeed, a main component of mindfulness-based meditation is the ability to regulate attention in order to maintain the focus on immediate experiences [25]. In their 2012 review on attentional functioning, Petersen and Posner stated that meditation training could be an interesting tool to develop attentional brain processes and networks [26]. Accordingly, reviews and meta-analyses show that extensive meditation practice is associated with brain structure and activity changes in a fronto-parietal network

associated to attentional functioning [26,27], and increased brain efficiency in these regions during performance on attentional tasks [28].

Changes in attentional functioning are present in normal ageing [29]. To date, encouraging preliminary evidence suggests that meditation practice may increase attentional efficiency in older adults. It was thus observed that long-term meditation practice has a protective effect against the age-related decrease of attentional functioning [17,30,31] and that short (8 to 12-weeks) meditation training can improve attentional functioning in healthy ageing [32,33] and in patients at risk of or with dementia [22,34,35].

In addition to the limitations outlined above, in the domain of attention it is not yet resolved whether the beneficial effects of meditation on attention in ageing are global or affect only specific processes, such as selective attention, or sustained attention. Further studies are needed to firmly establish the extent to which meditation can help improve attentional abilities in normal ageing and dementia, as the improvement of attentional abilities is prone to influence cognition and daily life functioning [13].

Meditation training can reduce negative affect and increase positive affect

Another route through which meditation training may benefit healthy ageing is through the reduction of negative affective states, such as anxiety and depression, and through the promotion of positive affective states, such as compassion. Symptoms of anxiety, depression, and stress are recognized as risk factors for cognitive decline and dementia [36-39], and meta-analytic evidence shows that meditation training can decrease these symptoms [40-42]. This beneficial effect of meditation on anxiety, depression and stress is confirmed by some preliminary studies in older adults [43-45]. In this context it is interesting to note that brain

structures, such as medial prefrontal cortex, anterior cingulate cortex and insula, which are affected by depression and anxiety [46], were shown to be preserved in expert meditators [9]. This may offer an insight into the brain mechanisms through which meditation may protect against depression, anxiety, and consequently dementia.

With regard to the promotion of positive emotions, meditation practices aimed at cultivating feelings of benevolence for oneself and others (including loving kindness and compassion meditation) have been particularly promising in young and middle-age adults. These trainings were found to broaden people's personal resources (such as purpose in life, social support and illness symptoms) through an increase in positive emotions [47], to increase helping behaviour [48] and to increase positive other-regarding emotions even when it comes to facing the suffering of others [49]. Furthermore, there are beneficial effects of compassion training versus a range of active control trainings in the domains of compassion, depression, anxiety, psychological distress and wellbeing [50].

While studies on the beneficial effects of meditation training on positive emotions in elderly are still scarce, first findings are encouraging. A study that compared the effects of 12 weeks of regular meditation training to 12 weeks of regular music listening in older adults with subjective cognitive decline found that meditation training improved mood and psychological well-being more than music listening [51]. Another study compared the effects of 8 weeks of meditation training to relaxation training in elderly [52]. This study found that participants in the meditation group evaluated negative pictures as more positive and positive pictures as less positive after the meditation training, while no changes in valence ratings were observed in the relaxation group [52]. This finding confirms previous findings of

increased positive affect to negative stimuli after meditation training [49] and suggests an increase in equanimity, as evidenced by the reduction in positive feelings to negative stimuli.

In the future, it would also be interesting to test in how far different forms of meditation training elicit specific effects. Affective meditation trainings, for instance, have been shown to be more efficient than mindfulness meditation trainings when it comes to decreasing cortisol levels, a physiological marker of stress, in response to a laboratory stress test [53]. In addition to cortisol, a wide range of biomarkers related to chronic stress and inflammation were reduced by meditation practices in various clinical populations [54]. The allostatic load [55], a cumulative measure of these biomarkers, appears to be a promising candidate to capture the effects of meditation training on stress-related physiological dysregulations across multiple systems.

Future Directions

Although meditation may be a promising intervention when it comes to promoting healthy ageing, randomized controlled studies with sufficiently large sample sizes, active control groups and a long-term follow-up are scarce in this domain. The inclusion of active control groups is particularly important, as older adults are particularly responsive to the effects of social activity [56], and mindfulness based interventions are often not superior to active control groups when it comes to psychological health and well-being [41,57]. Furthermore, it will be important for future studies to reduce risks in biases that may for instance stem from not blinding experimenters to the condition of the participants, to include biological measures in addition to self-reports, and to test the impact of meditation based trainings in elderly

and in populations at risk for dementia in the domains of brain structure, function and emotions.

The Medit-Ageing project received funding from the European Commission to investigate the impact of meditation training on mental health and well-being in the ageing population. The study uses a multi-method approach combining self-reports and a range of behavioural and biological measures (including measures of cognition, emotion, brain function, brain volume and blood-based biomarkers) to explore how individual characteristics modulate the impact of meditation on specific measures (e.g., if there is a link between baseline attentional abilities and the meditation effect on emotion regulation) and to identify common versus distinct mechanisms underlying the effects of meditation on different domains (e.g., is grey matter volume in the anterior cingulate cortex influencing the effect of meditation on both, attention and emotions). More specifically, the Medit-Ageing project is composed of three studies with older adults: i) the Age-Well observational study, a cross-sectional study comparing expert meditators to non meditators [58], ii) the Age-Well clinical trial, a longitudinal study in which an 18-month meditation intervention is compared to an active control group (English training) and a passive control group [59], and iii) the SCD-Well clinical trial [60], a longitudinal study in which participants with subjective cognitive decline, a known risk factor for dementia [61], are assigned to a 2-month meditation intervention (with 4-month follow-up) or a health education intervention [23,62]. To reduce the risk of bias, the longitudinal studies are clinical randomized controlled trials in which experimenters are blinded to the condition of the participants and in which data analyses of the primary endpoints are analysed externally. Importantly, both the 18-month and the 2-month interventions combine

elements of mindfulness especially tailored for elderly adults [63] and loving kindness and compassion meditations.

An important question that remains to be investigated in more depth in the future is in how far the effects of meditation interventions differ from other interventions, for instance those focusing on health, music, physical activity, or cognitive training and in how far mindfulness and compassion meditations have specific effects on ageing.

Figure Caption

Figure 1. Cross-sectional results point to preserved grey brain volume and glucose metabolism in 6 older-adult meditators compared to 67 age-matched controls. VMPFC-ACC: ventromedial prefrontal and anterior cingulate cortex; TP: temporo-parietal. Image modified with permission under the creative commons license (https://creativecommons.org/licenses/by/4.0/) from: [9].

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- •• of outstanding interest

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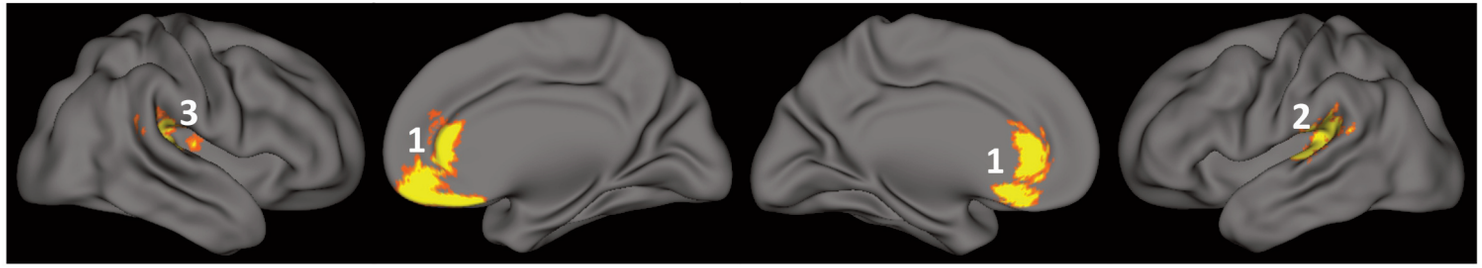
Grey Matter Volume

Significant increases in the elderly expert meditators

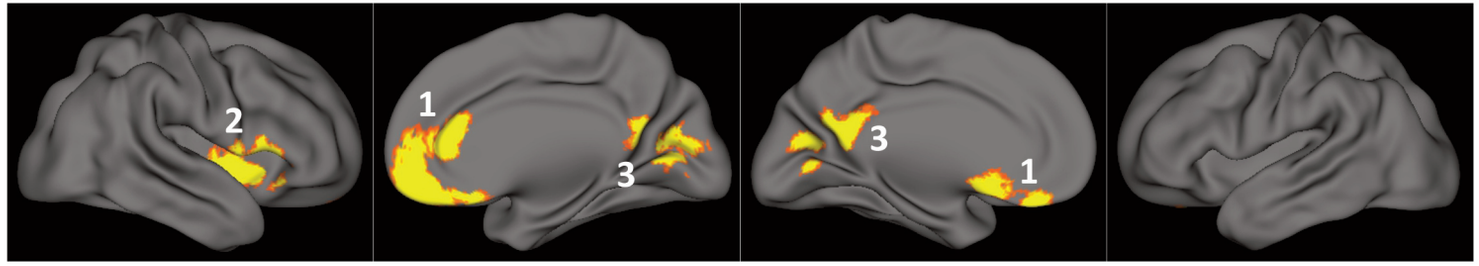


pv<0.001
pc(FWE)<0.05

1. VMPF-ACC
2. Left TP junction
3. Right TP junction

Grey Matter FDG Metabolism

Significant increases in the elderly expert meditators



pv<0.001
pc(FWE)<0.05

1. VMPF-ACC
2. Insula
3. Posterior cingulate cortex

Conflict of Interest Statement

The authors declare no conflicts of interest relation to contents of this paper.