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Review Article

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Meditation Research: A Narrative Review

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ABSTRACT

Current publications on meditation and mindfulness meditation are reviewed in this paper. The prevalence of meditation has been estimated at 18%. Psychological problems have been reduced by meditation including stress and depression. The physiological effects that have been reported for meditation include increased heart rate variability and decreased respiration rate, blood pressure, inflammation, pain, concussion symptoms, and sleep disturbances. Several neural functions have also been associated with meditation including increased functional integration in the default and salience networks, increased opioid activity, increased theta brain waves, decreased alpha brain waves, increased connectivity between brain regions, increased brain volume and decreased brain age. Surprisingly, a few negative meditation effects have also been reported including increased risk-taking, anxiety and depression. Methodological limitations include the separate study of variables that are related such as respiration and heart rate variability and brain connectivity and volume.

Meditation has been defined as a mind and body practice that uses techniques like focusing attention or breathing to calm the mind, reduce stress, and enhance overall well-being. The research for this narrative review involved entering the term meditation and the years 2024 to 2026 in PubMed and PsycINFO. Exclusion criteria included case studies, protocols and non-English language papers.

Different forms of meditation have appeared in the current literature on meditation. In a paper on 15 studies published between 2015 and 2020, several forms of meditation were described and the countries where they are widely practiced [1]. They include acceptance and commitment therapy (Portugal), active engagement (Portugal), adapted mindfulness (Brazil), cognitively based compassionate training and loving kindness (US), mantra meditation (US), mindfulness-based stress reduction (US), mindfulness meditation (US), mindfulness based cognitive therapy (South Korea), Osho (India), transcendental meditation (Italy), spiritual secular (US), Sufi (Pakistan) and Vipassana (Australia). Although specific countries were cited for different forms of meditation, most of the forms have been practiced in several countries and all of the forms have had positive effects.

Although these different forms exist, most of the studies found in the current literature were labeled meditation or mindfulness meditation. Mindfulness meditation has been defined as a practice of focusing attention on the present moment such as breath, body sensations or sounds while calmly accepting thoughts and feelings without judgment.

Papers in the current literature on meditation can be evenly divided between studies reporting positive effects and research on potential underlying biological mechanisms. The papers on positive effects are evenly divided between reducing psychological problems and decreasing physical conditions.

Positive Meditation Effects

Reducing Psychological Problems

Meditation has been noted to reduce psychological problems in this current literature (see table 1). The psychological problems that have been addressed include stress/distress and depression.

Table 1: Reducing Psychological Problems (And First Authors)

Psychological Problems	First Authors
Psychological Distress	Davies
Stress In General	Alhawatmeh
Stress in Paramedic Students	Little
Employee Stress	Radin
Stress in Fibromyalgia	Meng
Stress Reactivity	Mandik
Depressive Symptoms	Little, Meng, Fu

In the National Health Interview Survey (N= 134,959) that was conducted between 2002 and 2022, the prevalence of meditation was cited at 18% [2]. Indigenous Americans and those with **psychological distress** were over-represented in the prevalence

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data. Meditation use increased for 65+ year old adults, for people not accessing mental healthcare and for the less educated. Not surprisingly, meditation reduced their psychological distress.

Decreased stress in general was noted in at least five current studies on meditation. In one study on mindfulness meditation effects on perceived stress, the participants (N=102) were given eight weeks of meditation and were compared to a group who did not receive meditation [3]. Stress was reduced as were somatic symptoms, and and trait mindfulness was noted to increase. It's not clear how only 8 weeks of meditation could alter a trait such as mindfulness, but the participants may have given socially desirable ratings in the research for appreciating the meditation offerings.

In research on transcendental meditation effects on paramedic students (N= 10), decreased stress was noted [4]. A decrease in depression and an increase in trait resilience were also reported. Paramedic students who are known to have high stress levels associated with their work would be expected to benefit from stress reduction therapies. These results were statistically significant despite the small sample.

Digital meditation has been used to reduce employee stress in a randomized clinical trial [5]. Employees practiced meditation 10 minutes per day for eight weeks (N=1458, mean age =36). Perceived Stress Scale scores were decreased along with reduced job strain. These decreases were maintained at a four-month follow-up assessment. The employees likely continued digital meditation across the four months for the effects to be sustained for four months.

In a systematic review and meta-analysis (N=10 randomized controlled trials, N= 818 adults), stress decreased for those with fibromyalgia syndrome [6]. Insomnia and depression also decreased, and quality of life was improved. Not surprisingly, these effects were interrelated. Surprisingly, pain was not reported as a primary effect given that pain is the primary problem for those with fibromyalgia.

In another systematic review of 21 studies (N=2574), a single session of meditation led to a decrease in stress reactivity [7]. Decreased stress reactivity was reported in 71% of the studies measuring physiological responses and 65% of the studies using self-report psychological measures. These results were surprising given that a single session would likely involve new experience effects like concentration and anxiety that might exacerbate rather than alleviate stress reactivity.

Meditation has also decreased depression. This was already noted in the stress studies just reviewed [4,6]. **Depressive symptoms** were also reportedly decreased by mindfulness meditation in a systematic review and meta-analysis of 26 randomized controlled trials [8]. The typical reduction of depressive symptoms for participants in psychological research may relate to "faking good" socially desirable responses or appreciation for being guided through mindfulness meditation.

Reducing Negative Physiological Conditions

Several physiological changes were also reported for meditation (see table 2). They includes decreased respiration rate, increased heart rate variability, and decreased blood pressure, inflammation, pain, concussion symptoms, and sleep disturbances.

Table 2: Reducing Negative Physiological Conditions (And First Authors)

Physiological Conditions	First Authors
Heart Rate Variability	Zhou
Blood Pressure	Zhou, Khamal
Inflammation	Yu
Pain	Amorim
Migraine Headaches	Golshan
Preoperative Pain	Rajjoub
Neural Response to Pain	Pan
Neural Symptoms for Pain	Riegner
Concussion Symptoms	Callahan
Poor Sleep Quality	Li, Shi

In a systematic review on respiratory function in healthy, long-term meditators, **slower respiration rate** was noted in the meditators versus healthy control participants (N= 433) [9]. In addition, higher peak expiratory flow rates were noted in the long-term meditators. These respiration effects would be expected given that healthy, long- term meditators have been practicing breathing techniques long-term.

In a study entitled "Exploring the impact of different mindfulness meditation interventions" (N=48 college students), an eight-week mindfulness meditation group was compared to a sham intervention group [10]. The results of the mindfulness meditation intervention included **increased heart rate variability and decreased blood pressure.**

In a systematic review and meta- analysis entitled "The promising role of transcendental meditation in the prevention and treatment of cardiometabolic diseases", **blood pressure was reduced** [11]. Other positive effects included increased exercise and myocardial blood flow and decreased insulin resistance and dyslipidemia, effects that were likely reciprocally related.

In a systematic review of 11 reports (N=991) on the effects of mindfulness-based meditation on immune function of breast cancer patients, **decreased inflammation** was noted [12]. Increased immune cell counts and activity were also reported. The decreased inflammation would derive from meditation-related breathing and movement and the decrease in inflammation would then lead to enhanced immune activity.

In a study entitled "Mindfulness meditation reduces pain more effectively than slow-breathing meditation: the mediating role of respiration", the results are given in the title [13]. In this sample (N= 113 mindfulness meditation, 73 slow- breathing meditation and 60 in a book listening control group), mindfulness meditation was the most effective therapy for **reducing pain,** likely because of the reduced inflammation noted in the previous study.

In a randomized controlled trial of neurofeedback mindfulness meditation as a practice for migraine management, the participants with **migraine headaches** were asked to wear EEG headbands while they practiced mindfulness meditation 10 minutes daily for eight weeks (N= 101) [14]. This group was compared to a group that received an audiobook listening task. The mindfulness meditation group would be expected to benefit from that practice,

but the dropout rate was high with only 61 of 101 completing the study. Migraine headache participants may have found the EEG headbands uncomfortable and the mindfulness meditation sessions may not have been helpful as migraine headaches have been frequently treatment resistant.

Meditation has also been used as therapy for **preoperative pain and anxiety.** In a systematic review, both post-surgery pain and anxiety were reduced following meditation for those receiving meditation prior to their surgery [15]. This carryover effect from pre-surgery to post-surgery was surprising. The reduction in consciousness during surgery anesthesia may have enabled the pre-surgery meditation effects to re-emerge following surgery.

In a systematic review and meta-analysis of fMRI studies (N=18), meditation effects on **neural responses to pain** were reported [16]. Activation of the insula, anterior cingulate cortex and orbitofrontal cortex were positively associated with meditation for pain relief. Activity in the amygdala and medial prefrontal cortex were also correlated with pain relief. The simultaneous activation of these brain regions has been reported for several neural responses in addition to those for pain.

Mindfulness meditation has modulated distinct multivariate **neural signatures for pain** [17]. In this research (N=116), the mindfulness meditation group which received four sessions was compared with sham and book listening groups. As might be expected, the neural responses to pain occurred in the brain regions reported in the previous study [16].

Meditation has also reduced **concussion symptoms.** In a study entitled, "Feasibility and preliminary effectiveness of an online meditation intervention in young adults with concussion history", the participants engaged in 10 to 20-minute per day online guided meditations for six weeks [18]. This online guided meditation reduced concussion symptoms. Given that headaches are the primary symptom of concussions, and headaches respond to meditation, as previously reported, it's not surprising that meditation reduced that symptom [14].

Sleep has also benefited from meditation. In a meta-analysis entitled "The effect of meditation – based mind – body interventions on older adults with poor sleep quality", 11 randomized controlled trials were included on tai chi, yoga and qi gong (N= 1052) [19]. In addition to improved sleep quality, both depression and anxiety were decreased. However, the meditation effects in this study were confounded by the more physical interventions of tai chi, yoga and qi gong, which might be expected to have stronger effects than meditation as they involve not only the mind but also the body. Although sleep, depression and anxiety have been noted to benefit from these interventions, they have, surprisingly, not been compared. Comparisons could inform the adoption of clinical interventions.

In another meta-analysis, meditation was provided for adults with cognitive decline, cognitive impairment and Alzheimer's [20]. Cognitive performance and health status improved across 25 randomized controlled trials (N=2095). Sleep quality also improved which would be expected following improved health status.

Neural Function Effects

Several neural functions have been positively affected by meditation (see table 3). They include increased functional integration in the default and salience networks, increased opioid activity, increased theta brain waves, decreased alpha brain waves, increased connectivity between brain regions, increased brain volume and decreased brain age. Although these measures have been studied independently, they would be expected to be interrelated.

Table 3: Neural Function Effects (And First Authors)

Neural Function Effects	First Authors
Functional Integration in the Default Mode	Jinich-Diamant
Functional Integration in the Salience Mode	Jinich-Diamant
Endogenous Opioids	Jinich-Diamant
Default Mode Network Activity	Sim
Modulated Brain Activity	Ploesser
Theta Waves and Alpha and Beta Waves	Duda

In a study on neural and molecular changes during a mind-body meditation (N= 20), fMRIs suggested **increased functional integration in the default mode and salience networks** [21]. **Increased endogenous opioid** and modulated tryptophan metabolism were also noted in the meditation group. Both chemical measures would be expected to be related to the brain function measures. However, directionality cannot be concluded from this cross-sectional study.

In a scoping review of neural correlates resulting from fMRIs conducted during mindfulness meditation and hypnosis, both similarities and differences were noted (N=97 papers including 84 for mindfulness meditation and 13 for hypnosis) [22]. The similar effects of the two forms of intervention were **increased default mode network activity** and increased central mode – salience network connectivity. The difference was that increased connectivity between the default mode network and the salience network was noted for mindfulness meditation but not for hypnosis. That unique effect for mindfulness meditation versus hypnosis might be expected given the greater physical activity that might occur during mindfulness meditation versus hypnosis.

In a systematic review and meta-analysis of 21 studies (5 clinical and 16 experimental pain induction studies), **modulated brain activity** was reported for the anterior cingulate cortex, the anterior insula and the orbitofrontal cortex [23]. Increased activity in these salience and attentional control regions would be expected as they are pain activated regions. However, methodological problems with these studies have included the predominance of healthy samples and the variable protocols of the different studies.

Mindfulness meditation was also associated with global EEG spectral changes in theta, alpha, and beta amplitudes in a study on healthy adults (N=40) [24]. In this database, **theta waves increased and alpha and beta waves decreased,** suggesting increased relaxation.

Negative Effects

Surprisingly, at least two research groups have reported negative meditation effects (see table 4). The negative effects included increased risk-taking and increased anxiety and depression. In one study entitled "Brief mindfulness meditation increased risk-taking behavior", the results are in the title of this study

conducted in the UK and Singapore [25]. The authors suggested that **increased risk-taking behavior** was related to a "decrease in loss aversion during decisional processing". This interpretation is somewhat vague, but it is conceivable that mindful meditation might increase self-confidence that could in turn enable risk-taking behavior.

Table 4: Negative Effects of Meditation (And First Authors).

Negative Effects	First Authors
Risk-Taking Behaviors	Lucy
Anxiety and Depression	Matko

Surprisingly, **increased anxiety and depression** were noted in a study entitled "Beyond serenity: adverse effects of meditation mindfulness in clinical practice" [26]. In this sample, 25 to 87% of the meditation participants reported adverse effects (3–37% experienced functional impairment, e.g. inability to work). The common adverse effects were anxiety, depression, and traumatic re-experiencing. Attendance at retreats and pre-existing mental health conditions increased the risk of adverse effects. Both the retreat attendance and pre-existing mental health conditions might be expected to contribute to anxiety and depression. And, meditation might lead to traumatic re-experiencing as some meditation protocols have been focused on re-experiencing traumatic events.

In a review entitled " Mindfulness meditation science: review, synthesis and future directions", a **shift was noted in several regions of the brain** [27]. The regions included the anterior cingulate cortex, the thalamus and the mid – insula.

A 31-day mindfulness meditation training was provided for mindfulness meditation naïve participants (N=66) [28]. **Functional connectivity changes** were noted between the hypothalamus, reward regions, and the default mode network. Behavior changes included reduced stress, emotional eating and food cravings. These behavior and neural changes were correlated.

In a study entitled "EEG brain rhythms during resting – state wakefulness and sleep in elderly expert meditators", no group differences were noted on self-reported sleep quality in expert versus non-expert meditators (N= 73) [29]. More **preserved brain activity** was noted at rest. Sleep architecture and EEGs suggested greater cognitive states during NREM sleep.

In research entitled "Impact of meditation on brain age derived from multimodal neuroimaging in experts and older adults", 25 older expert meditators with greater than 20 years of practice and 135 cognitive unimpaired older adults were compared on brain age [30]. The long-term meditators who had 18 months of training had **younger brain age,** but the 18 months of training had no effect. These results are tenuous because of the extremely unequal sample sizes.

In a study by the same research group on the same samples (and equals 27 older and 135 controls) meditators had **greater volume** in frontal – parietal areas [30]. The meditators also had more positive psycho – affective scores. Attention and constructive mechanisms mediated the links between brain differences and the scores.

Striatal functional connectivity has also been associated with meditation [31]. In this sample (23 meditators and 23 non–meditators), greater connectivity between the striatum and the parietal sensorimotor and cerebellar regions was noted. This connectivity occurred during meditation versus rest.

In a paper entitled "Comparing neural correlates of consciousness: from psychedelics to hypnosis and meditation", pharmacological and non-pharmacological differences were noted in functional connectivity [32]. In this sample (N= 30 in each group), hypnosis and meditation also had different functional connectivity.

The post cingulate cortex has also been noted to have functional connectivity with the hippocampus and that connectivity was associated with stress biomarker changes after meditation training for chronically stressed adults (N=94) [33].

Methodological Limitations of this Literature

In a critical review of meditation studies, several methodological limitations were noted [34]. These included the variable definitions of meditation across the studies, and the practices that have differed in techniques, goals and outcomes. The research protocols have lacked standardization, and the participants have had different experiences, motivation, and characteristics. The authors noted the need to stratify samples by characteristics. They also suggested that this area of research lacks a theoretical framework. Repeated measures have yielded different results. These authors concluded by suggesting that future research needs to combine qualitative and quantitative methods.

Additional methodological limitations are the homogeneity of the white university student samples. In addition, the researchers have typically focused on single variables rather than the multiple variables that are interrelated, for example respiration and heart rate variability and brain connectivity and volume. Multivariate studies using stepwise regression or structural equation modeling would determine the relative significance of the variables. Despite these limitations, this current literature has been informative and suggestive of future research on meditation effects.

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