Mindfulness Interventions

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Abstract

Mindfulness interventions aim to foster greater attention to and awareness of present moment experience. There has been a dramatic increase in randomized controlled trials (RCTs) of mindfulness interventions over the past two decades. This article evaluates the growing evidence of mindfulness intervention RCTs by reviewing and discussing (*a*) the effects of mindfulness interventions on health, cognitive, affective, and interpersonal outcomes; (*b*) evidence-based applications of mindfulness interventions to new settings and populations (e.g., the workplace, military, schools); (*c*) psychological and neurobiological mechanisms of mindfulness interventions; (*d*) mindfulness intervention dosing considerations; and (*e*) potential risks of mindfulness interventions. Methodologically rigorous RCTs have demonstrated that mindfulness interventions improve outcomes in multiple domains (e.g., chronic pain, depression relapse, addiction). Discussion focuses on opportunities and challenges for mindfulness intervention research and on community applications.

Contents

INTRODUCTION

> There are few people I know on the planet who couldn't benefit more from a greater dose of awareness.
>
> —Jon Kabat-Zinn (on Bill Moyers, *Healing and the Mind*)

Readers not familiar with mindfulness meditation practices or mindfulness interventions might try a quick exercise: close your eyes for about a minute and maintain an open awareness of the sensations of breathing at your nostrils. There is no need to do anything special, just continuously observe the sensations of breathing in and breathing out at the nostrils with curiosity and interest. Even doing a one-minute mindfulness exercise like this can reveal that our minds are quick to race off to other places. For example, you might have thought about planning dinner tonight, drifted off, or noticed a strong desire to consciously control how you were breathing. Moreover, there is often a rich kaleidoscope of experiences and emotional reactions, including relaxation or agitation, occurring even in a short exercise such as this. Formal mindfulness training exercises, such as learning how to mindfully attend to breathing, form the backbone of many mindfulness interventions. Collectively, mindfulness interventions aim to foster greater awareness of present moment experience, which, as Jon Kabat-Zinn suggests in the quote in the epigraph of this review, may have manifold benefits ranging from enhancing the quality and vividness of our daily life experience to helping us better manage life's slings and arrows.

Mindfulness: a process of openly attending, with awareness, to one's experience in the present moment

Interest in mindfulness interventions has increased exponentially over the past three decades. Much of this interest has been fueled by scientific reports and corresponding media coverage describing the potential benefits of mindfulness interventions for a broad array of outcomes, ranging from mental and physical health outcomes (Ludwig & Kabat-Zinn 2008) to cognitive, affective, and interpersonal outcomes (Brown et al. 2015). Mindfulness interventions are also increasingly being integrated into institutional settings—in clinical treatment (Dimidjian & Segal

2015), the workplace (Good et al. 2016), schools (Sibinga et al. 2016), the military (Johnson et al. 2014), and prisons (Samuelson et al. 2007), to name only a few. This proliferation of interest in mindfulness interventions has been met by the scientific community with a wide range of reactions, from skepticism to fanaticism. This review evaluates what we have learned from randomized controlled trials (RCTs) of mindfulness interventions in terms of their effects, applications to new populations, putative mechanisms, dosing questions, and potential risks.

RCT: randomized controlled trial

What Is Mindfulness?

There has been a rich scholarly dialogue about how to define mindfulness as a construct. One working definition of mindfulness is a process of openly attending, with awareness, to one's present moment experience. This process of awareness of present moment experience contrasts with much of our daily life experience, in which we often find ourselves unintentionally letting our minds wander (Killingsworth & Gilbert 2010), running on automatic pilot (Bargh & Chartrand 1999), or suppressing unwanted experiences (Kang et al. 2013). Moreover, the mindless states that predominate in our daily life experience have been demonstrated to be undesirable. For example, one study showed that our minds wander approximately 47% of the time and that mind wandering predicts subsequent unhappiness (Killingsworth & Gilbert 2010). In contrast, the capacity to be mindful is associated with higher well-being in daily life (Brown & Ryan 2003).

Mindfulness has been operationalized in many different ways in the scientific literature (for a review, see Quaglia et al. 2015). Two features appear in most definitions of mindfulness. First, mindfulness grounds attention and awareness in one's present moment experience. The present moment experience that one attends to can take many forms, including one's body sensations, emotional reactions, mental images, mental talk, and perceptual experiences (e.g., sounds). Scholars have described this monitoring feature of mindfulness as "watchfulness" or a "lucid awareness of each experience that presents itself" (Bodhi 2011, Brown et al. 2007, Quaglia et al. 2015). Second, many contemporary conceptualizations of mindfulness posit that adopting an attitude of openness or acceptance toward one's experience is critical. This open and accepting attitude consists of attending to experience with a curious, detached, and nonreactive orientation. Importantly, this attitude of acceptance toward experience is not one of passive resignation to one's current circumstances but rather one of inviting in experiences, even if they are difficult.

Although psychological scientists have been interested in mindfulness for the past three decades, this is a thin slice of scholarly work relative to the 2,500-year tradition of scholarship about (and practice of) mindfulness interventions in many Buddhist traditions (Anālayo 2003). Buddhist scholarship has thus informed a great deal of the psychological research on mindfulness and mindfulness interventions, but mindfulness is by no means exclusive to Buddhism or Buddhist contemplative practices. First, most of the mindfulness interventions now tested in the scientific literature are secular in nature. Second, being mindfully aware is not synonymous with being a Buddhist; it is instead a basic feature of being human.[1] As Bhante Gunaratana (2011, p. 146) states in his classic mindfulness training text, "Mindfulness is not limited by any condition. It exists to some extent in every moment, in every circumstance that arises." Similarly, Jon Kabat-Zinn (2003,

[1]It is possible that many cultural practices in human history have been developed to help foster mindful awareness (e.g., centering prayer, journaling, surfing, psychotherapy). Indeed, some work suggests that training in tango dancing increases self-reported mindfulness (Pinniger et al. 2012). Many open questions remain about the role of various cultural practices in fostering mindfulness or the ways in which these factors might interact with formal mindfulness training interventions. In one intriguing case in point, cultural anthropologists have described a more mindful culture: The Amazonian Piraha tribe's cultural practices and language are geared toward helping individuals to be more grounded in present moment awareness, and members report high degrees of daily well-being (Everett 2005).

pp. 145–46) has written, "We are all mindful to one degree or another, moment by moment." Thus, we all have the capacity to openly pay attention to our moment-to-moment experience, and this capacity is something that can be developed and deepened by mindfulness interventions.

Although everyone is capable of mindfulness, formal mindfulness intervention exercises can feel quite effortful and challenging at first. This is understandable given that our default methods of attending to experience are commonly letting our minds wander, engaging in self-criticism, ruminating about the past, or worrying about the future. Tellingly, one study showed that participants preferred receiving mild electric shocks over being left alone with their thoughts (Wilson et al. 2014). Formal mindfulness intervention exercises require one to make deliberate efforts to turn toward and sustain attention on moment-to-moment experience. To borrow an expression from cognitive science, this effort of attending to present moment experience may be a desirable difficulty (Bjork & Bjork 2011) such that the effort put forth during mindfulness training exercises can foster insight, learning, and self-regulation skills.

TAU: treatment as usual

Wait-list control: refers to participants who are randomized to serve as a no-treatment comparison group and placed on a wait list to receive a mindfulness intervention

Mindfulness-based stress reduction (MBSR): an 8-week mindfulness meditation training program that includes weekly classes, daily audio-guided home practice, and a day-long retreat

Types of Mindfulness Interventions

Much of the early work on mindfulness interventions used nonrandomized pretest posttest designs; however, beginning in the early 2000s, there was a dramatic increase in RCTs that compare mindfulness interventions to treatment as usual (TAU), wait-list control, or active comparison interventions (see **Figure 1**). This section describes some of the most common types of mindfulness and control interventions used in the scientific literature.

Mindfulness-based stress reduction and related group-based mindfulness interventions. The 8-week mindfulness-based stress reduction (MBSR) program, developed by Jon Kabat-Zinn at the University of Massachusetts Medical School, is perhaps the most well-known mindfulness

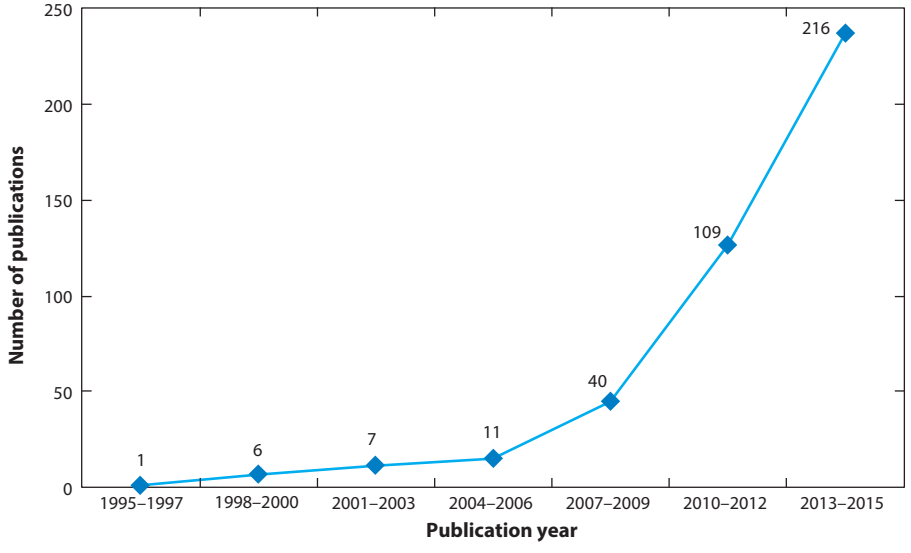

Figure 1

A noncumulative plot of the number of mindfulness randomized controlled trials (RCTs) published during 3-year periods between 1995 and 2015. The data were gathered from a PubMed abstract/title search (in February 2016) of human clinical trial studies using the terms mindfulness and randomized controlled trial.

intervention in the scientific literature (Kabat-Zinn 1982). MBSR consists of weekly 2–2.5-h group-based classes with a trained teacher, daily audio-guided home practice (approximately 45 min/day), and a day-long mindfulness retreat (occurring during week 6 of the 8-week program) (Kabat-Zinn 1990). Much of the MBSR program focuses on learning how to mindfully attend to body sensations through the use of body scans, gentle stretching, and yoga mindfulness exercises, along with discussions and practices geared toward applying mindful awareness to daily life experiences, including dealing with stress. The MBSR program was initially used to treat chronic pain patients (Kabat-Zinn 1982) but has been applied to many other populations of adult patients and community members (Ludwig & Kabat-Zinn 2008).

Mindfulness-based cognitive therapy (MBCT): an 8-week mindfulness-based program that combines elements of MBSR and CBT

MBRP: mindfulness-based relapse prevention

Over the past three decades, MBSR has stimulated the development of many mindfulness interventions that share the same basic program structure but are modified to treat specific populations or outcomes. These interventions have focused on treating depression [mindfulness-based cognitive therapy (MBCT); e.g., Teasdale et al. 2000] and drug addiction [mindfulness-based relapse prevention (MBRP); e.g., Bowen et al. 2014], fostering healthy eating (Mason et al. 2015), and improving relationship functioning [mindfulness-based relationship enhancement (MBRE); Carson et al. 2004], among other applications (for a review, see Dimidjian & Segal 2015).

Mindfulness intervention retreats and brief interventions. The scientific community has often assumed MBSR and other 8–12-week mindfulness-based programs are the exclusive way to deliver mindfulness training, but there are other evidence-based forms of mindfulness intervention available to researchers and practitioners. Mindfulness meditation residential retreat programs ranging from 3 days to 3 months are a powerful way to deliver intensive and well-controlled doses of mindfulness intervention (Creswell et al. 2016, Rosenberg et al. 2015). Brief mindfulness meditation interventions have also been developed, ranging from 2–3-week programs (Lim et al. 2015, Mrazek et al. 2013) to lab-based 3–4-day mindfulness interventions (Creswell et al. 2014, Zeidan et al. 2011). Finally, brief experimental mindful attention inductions have been developed and tested in the literature (e.g., Broderick 2005, Papies et al. 2015, Schofield et al. 2015, Westbrook et al. 2013). These induction approaches offer a great deal of experimental control but have relatively small and transient effects.

Internet and smartphone application mindfulness interventions. There has been an explosion of Internet- and smartphone-based mindfulness programs hitting the market over the past five years. One example of this trend, the Headspace mindfulness smartphone app, has over two million active users worldwide. Given that so many people are using these programs (which lack, in most cases, access to a well-trained mindfulness teacher), there are important untested questions about the safety and efficacy of these programs. However, these mindfulness intervention programs have a tremendous advantage in that they are inexpensive and portable and can be more easily implemented in harder-to-reach populations that can access the Internet. Although there has been no research on the efficacy of these programs compared to in-person group-based approaches (e.g., MBSR), initial studies suggest that these Internet and smartphone mindfulness interventions may have benefits (e.g., Boettcher et al. 2014, Lim et al. 2015).

Mindfulness-related interventions. The objective of this article is to review mindfulness-based interventions in which the primary goal is to foster mindfulness (e.g., MBSR, MBCT, brief mindfulness meditation training interventions). However, there are also many mindfulness-related interventions which incorporate mindfulness training exercises as one component of a broader treatment program (e.g., acceptance and commitment therapy, dialectical behavior therapy,

cognitive behavioral stress management, integrative body–mind training). Initial efficacy evidence suggests that incorporating mindfulness training exercises in these interventions can be beneficial to patients. Space considerations preclude a careful review of these mindfulness-related interventions in this article, but published reviews are available for interested readers (e.g., Hayes et al. 2011).

Health enhancement program (HEP): an 8-week health education and relaxation program developed to be a well-matched comparison program to MBSR

Control interventions. It is important to consider the comparison groups used in RCT studies of mindfulness interventions (Davidson & Kaszniak 2015), and most published mindfulness intervention RCTs use TAU or wait-list controlled comparison groups. These studies provide a valuable initial evaluation of whether mindfulness interventions have an impact on outcomes above and beyond standard care or no treatment. Researchers have made impressive efforts to develop active treatment comparison programs that control for non-mindfulness-specific treatment factors (e.g., group support, home practice exercises, relaxation, placebo expectancies). These programs provide opportunities to evaluate whether mindfulness interventions have unique treatment effects above and beyond non-mindfulness-specific factors and whether mindfulness interventions can outperform gold-standard active pharmacological or behavioral treatments.

There are many different active treatment programs used as comparisons in the RCT literature on mindfulness interventions. The health enhancement program (HEP) is an 8-week health education and relaxation program that was developed to match MBSR on program components, including group support and education, home practice, and a day-long retreat (MacCoon et al. 2012). Other active group-based interventions ranging from relaxation interventions (Creswell et al. 2016) to targeted health education programs (Morone et al. 2016) have been effectively implemented. The literature on brief mindfulness interventions (consisting of interventions that last 2 weeks or fewer) also offers a number of well-matched active control interventions ranging from attention control training programs (e.g., listening to the same guided mindfulness exercise with the instruction to count the number of verbs) (Koole et al. 2009, Schofield et al. 2015) to placebo conditioning (Zeidan et al. 2015) and health education interventions (Mrazek et al. 2013). One intriguing new approach to brief mindfulness interventions offers sham mindfulness meditation training in which participants are periodically instructed "to take a deep breath as we sit here in mindfulness meditation" without any explicit instructions on how to foster mindful awareness (Zeidan et al. 2015, p. 15,309). This sham mindfulness procedure has been effective in controlling for positive treatment expectancies in studies but does not provide the same pain-relief benefits as actual mindfulness meditation training (Zeidan et al. 2010b, 2015).

EFFECTS OF MINDFULNESS INTERVENTIONS

Mindfulness interventions have been shown to impact a broad range of outcomes in RCTs. Despite this proliferation of work, most mindfulness intervention RCTs have used small samples and lack high-quality pretreatment, posttreatment, and follow-up measures. These methodological limitations make it difficult to draw strong inferences about the validity and reliability of mindfulness intervention effects on many outcomes. However, some areas show quite promising mindfulness intervention RCT effects; these effects are selectively reviewed in the following sections with a focus on recent developments in this active area of scientific inquiry. This review focuses on mindfulness-based intervention RCTs and not on studies of other forms of meditation interventions (e.g., transcendental meditation), cross-sectional studies of expert mindfulness meditators, or correlational studies relating self-report measures of mindfulness to outcomes (for a more general review, see Brown et al. 2007).

Physical Health

CBT: cognitive behavioral therapy

The earliest work with the MBSR program was focused on treating chronic pain patients who were not responding well to traditional medical treatments (Kabat-Zinn 1982), demonstrating the long-standing scientific interest in applying mindfulness interventions to the treatment of physical health. Much of the interest in this physical health domain has been guided by views that mindfulness interventions can foster greater body (interoceptive) awareness, promote relaxation, and improve stress management and coping skills, all of which can promote physical health and reduce disease risks. We have formalized a mindfulness stress-buffering account, which posits that stress reduction and resilience pathways explain mindfulness intervention effects on a broad range of physical health outcomes (Creswell & Lindsay 2014). This account is based on the view that learning how to monitor experience with acceptance is an emotion regulation skill learned in mindfulness interventions, which fosters stress resilience and coping under stress. Furthermore, these stress-buffering effects in turn reduce the negative impacts stress has on increasing risk for stress-related disease outcomes. Consistent with this account, a growing number of rigorous RCT studies show that mindfulness interventions impact stress-related physical health outcomes ranging from chronic pain to immune system functioning to disease-specific physical health outcomes.

Chronic pain. Stress is a powerful trigger for pain symptomatology among chronic pain patients (Schwartz et al. 1994), and early nonrandomized studies showed that MBSR was effective in reducing pain symptoms and dependence on pain-relief medication among chronic pain patients pre-post intervention (Kabat-Zinn 1982, Ludwig & Kabat-Zinn 2008). Several independent well-controlled studies have conceptually replicated and extended this work. Morone and colleagues (2016) showed that MBSR, relative to an active healthy aging program, was effective in reducing self-reported pain disability posttreatment in a large RCT with adults suffering from chronic low-back pain ($N = 282$), although these pain-related benefits were not sustained at the 6-month follow-up assessment. E.L. Garland and colleagues (2014) showed that, relative to an active support group therapy program, an 8-week mindfulness-oriented recovery enhancement (MORE) program reduced pain severity and pain interference among chronic pain opioid-abusing patients posttreatment and at a 3-month follow-up. In a daily diary study of adults with rheumatoid arthritis ($N = 143$), Davis and colleagues (2015) showed that an 8-week mindfulness training program was superior to a cognitive behavioral therapy (CBT) program for pain and an arthritis education program in reducing posttreatment daily-level stress, pain-related catastrophizing, disability, and fatigue. In one of the largest mindfulness intervention RCTs to date ($N = 342$), MBSR reduced functional limitations due to pain among chronic back pain participants at both 4-month and 10-month follow-ups compared to TAU (Cherkin et al. 2016). Although this large RCT study showed that MBSR provided a clinically meaningful improvement in pain management in a greater percentage of participants at follow-up (61%) relative to TAU (44%), there was no evidence in this study that MBSR was superior to a matched CBT program (58%).[2]

Immunity. The immune system plays a central role in protecting the body from a variety of pathogens and infectious agents. Chronic stress impairs several aspects of the immune system's

[2]Given the promising evidence for pain management effects of mindfulness intervention, one interesting question is whether these mindfulness pain reduction effects are driven by alterations in pain sensation processing or by fostering the regulation of one's emotional reactivity to pain (i.e., reducing pain unpleasantness). Some initial evidence suggests that mindfulness interventions can modulate both neural sensory and emotional reactivity pain pathways (Zeidan et al. 2011).

functional response, including its capacities to mount antibody responses and to produce lymphocyte proliferative and natural killer cell responses (for a review, see Segerstrom & Miller 2004). Furthermore, stress has been linked to increases in C-reactive protein and interleukin 6, which are circulating markers of inflammation linked with morbidity and accelerated mortality. Mindfulness interventions may potentially modulate these stress-related immune outcomes, and initial RCTs demonstrate promising effects on some immune markers (for a review, see Black & Slavich 2016). For example, several initial well-controlled studies show that mindfulness interventions may reduce markers of proinflammation, including circulating blood markers of C-reactive protein (Malarkey et al. 2013), interleukin 6 (Creswell et al. 2016), and the stress-induced inflammatory skin flare response (Rosenkranz et al. 2013) (although MBSR failed to affect stimulated interleukin 6 responses in rheumatoid arthritis patients; see Zautra et al. 2008). In contrast to inflammatory effects, the evidence of mindfulness interventions' effects on antibody levels or the antibody response to vaccination is mixed (Hayney et al. 2014, Moynihan et al. 2013).

Stress also plays an important role in the acceleration of HIV infection and the development of AIDS, in part by attacking $CD4^+$ T lymphocytes. Three RCTs show that mindfulness interventions can buffer declines in or increase $CD4^+$ T lymphocyte counts in stressed HIV-positive adults at posttreatment and at follow-up time points up to 9 months later (Creswell et al. 2009, Gonzalez-Garcia et al. 2013, SeyedAlinaghi et al. 2012).

Clinical symptoms and disease-specific outcomes. Some of the most encouraging RCT research on the relationship between mindfulness intervention and physical health focuses on whether mindfulness interventions affect clinically relevant measures of health and disease. An initial large RCT ($N = 154$) showed that MBSR may reduce the number of self-reported illness days and the duration of illness over the course of a cold and flu season relative to a no-treatment group (Barrett et al. 2012). However, in this trial, MBSR showed no relative advantage in illness-related outcomes compared to a moderate aerobic exercise program, although there was some evidence that MBSR reduced the total number of acute respiratory infection–related work days missed (16 days) compared to the aerobic exercise (32 days) and no-treatment control (67 days) groups. Some initial large well-controlled RCT studies have also showed that mindfulness interventions (relative to controls) reduce physical symptoms and improve quality of life in fibromyalgia patients (Schmidt et al. 2011), in women with irritable-bowel syndrome (IBS) (Gaylord et al. 2011), and among distressed breast cancer survivors (Carlson et al. 2013). Finally, there is some initial evidence that brief audio-guided mindfulness training practices during light-booth phototherapy can accelerate skin clearing in psoriasis patients; one trial showed a fourfold-faster clearing rate in the mindfulness intervention group relative to TAU (Kabat-Zinn et al. 1998). Some researchers have questioned whether the group training context is necessary for mindfulness intervention benefits, and this psoriasis study joins others that have trained participants individually (with audio-guided mindfulness practices only) and showed benefits independent of a group context (see also Creswell et al. 2014, Zeidan et al. 2011).

Health behaviors. Stress is known to disrupt health behaviors such as sleep, exercise, smoking, and diet, and these stress-related disruptions in health behaviors negatively impact physical health and disease outcomes. Despite these established links, little rigorous empirical work has tested whether mindfulness interventions impact health behaviors. There is some initial RCT evidence that mindfulness interventions can reduce smoking among heavy smokers (Brewer et al. 2011), alter dietary behaviors such as eating sweets (Arch et al. 2016, Mason et al. 2015), and improve self-reported and polysomnographic markers of sleep (although the sleep outcomes evidence is mixed; see Black et al. 2015; Britton et al. 2010, 2012; S.N. Garland et al. 2014).

Interim summary of physical health effects. Several large RCTs provide compelling evidence that mindfulness interventions improve chronic pain management relative to TAU, with some initial evidence that mindfulness interventions may be superior to some active treatments (support groups, health education programs) but not to other treatments (CBT). There is also promising initial evidence that mindfulness interventions may reduce immune markers of proinflammation among stressed individuals and buffer declines in $CD4^+$ T lymphocytes in HIV-infected adults, although large well-controlled trials are needed to evaluate the links between mindfulness and immunity. Mindfulness interventions may reduce symptoms and improve quality of life across a broad range of stress-related conditions (e.g., fibromyalgia, IBS, breast cancer, psoriasis); however, relatively little is currently known about how mindfulness interventions affect health behaviors.

Mental Health

There is a great deal of interest among clinical psychologists in using mindfulness interventions to treat a broad range of mental health outcomes. Indeed, some clinical scientists have posited that mindfulness and acceptance interventions are a third-wave treatment approach, following behavioral and cognitive-behavioral treatment approaches (Hayes et al. 2004). This interest among clinicians has in part been built on views that mindfulness interventions can help individuals notice and regulate the maladaptive thoughts, emotional responses, and automatic behaviors that underlie mental health problems.

Depression relapse. Some of the strongest evidence to date in the mindfulness intervention literature shows that the MBCT program is effective in reducing depression relapse during follow-up periods in at-risk populations. Several RCTs demonstrate that 8-week MBCT is a cost-effective treatment that significantly reduces the risk of depression relapse compared to TAU among individuals who have had three or more previous major depressive episodes in their lifetimes (e.g., Ma & Teasdale 2004, Teasdale et al. 2000). This impressive body of work has made use of careful clinician condition-blinded assessment of depression during long-term follow-up periods ranging from 12 months to 2 years, with studies demonstrating that MBCT reduces depression relapse by approximately 50% relative to TAU during these periods. Furthermore, these MBCT benefits seem to be most pronounced among those at the greatest risk for relapse, such as individuals with four or more previous major depressive episodes (Ma & Teasdale 2004) or individuals who suffered from maltreatment during childhood (Ma & Teasdale 2004, Williams et al. 2014). Many at-risk individuals prefer not to use antidepressant medications (e.g., during pregnancy or to avoid side effect symptoms), and two RCTs indicate that MBCT (with a 4-week taper-off of antidepressant medications during the 8-week program) has depression relapse prevention benefits equivalent with maintenance antidepressant medication treatments during 18–24-month follow-up periods (Kuyken et al. 2015, Segal et al. 2010); however, a recent trial suggests that the combination of MBCT with maintenance antidepressant medication may be optimal (Huijbers et al. 2016).

Depression and anxiety symptoms. The previous section highlights the benefits of offering mindfulness interventions to individuals who are not currently depressed but are at risk for depression relapse; might mindfulness interventions also help individuals with mood disorders who are currently experiencing high levels of anxiety or depressive symptoms? Mindfulness interventions aim to foster an open and accepting awareness of one's thoughts and feelings, including an observant attitude toward the thought patterns and body experiences that occur when

PTSD: posttraumatic stress disorder

one feels acutely anxious or depressed. This process of turning attention and awareness toward these experiences has been posited to help reduce the experiential avoidance, self-judgment, and rumination that are often triggered by acute depression and anxiety (Roemer & Orsillo 2009). Some initial well-controlled studies indicate that MBCT may be effective in reducing depressive symptoms among acutely depressed individuals (e.g., Strauss et al. 2014). In one of the best-controlled trials to date, Eisendrath and colleagues (2016) tested a modified MBCT program for treatment-resistant depression and showed that MBCT reduced depressive symptoms posttreatment compared to a well-matched HEP comparison program in a sample of treatment-resistant depressed patients. These mindfulness intervention effects were specific to reducing depressive symptoms; there were no differences between the MBCT and HEP groups in the depression remission rates posttreatment.

Meta-analyses indicate that mindfulness interventions significantly reduce anxiety among anxiety-disordered populations pre-post intervention but are mixed about whether this effect is greater than that of control programs (Strauss et al. 2014, Vøllestad et al. 2012). Furthermore, there is little evidence that mindfulness interventions are better than CBT interventions for anxiety symptom reduction (Goldin et al. 2016), although some work suggests that MBSR may be more effective for participants with moderate-to-severe dysphoria whereas CBT may be more effective for participants with mild dysphoria in anxiety disorder groups (Arch & Ayers 2013). Trials conducted since these meta-analyses show that mindfulness training may be effective in reducing anxiety symptoms compared to some active treatments. For example, a recent Internet-based mindfulness intervention was effective in reducing anxiety posttreatment compared to a supervised online discussion group program (Boettcher et al. 2014). Hoge and colleagues (2013) also showed that MBSR reduced some measures of anxiety symptoms (including anxiety in response to a laboratory social stress challenge task) compared to an active stress-management education program group in a sample of participants with generalized anxiety disorder (Hoge et al. 2013). Mood disorders are prevalent among individuals with posttraumatic stress disorder (PTSD), and initial well-controlled evidence in Vietnam War veterans indicates that MBSR reduces self-reported and clinician-rated PTSD symptomatology 2 months posttreatment (Polusny et al. 2015).

Addiction and addictive disorders. All humans have experienced cravings at one time or another and have felt the strong pull to act on them with consummatory behaviors such as eating, having sex, or using addictive substances. These behaviors can sometimes spiral out of control into addictions (e.g., to alcohol, gambling, smoking) when engaging in them interferes with daily life functioning or causes harm to the self or others. Mindfulness interventions foster an ability to observe the rise and fall of cravings and the behaviors they encourage and offer the opportunity to meet these experiences with more skillful action. Thus, mindfulness interventions have tremendous potential to address craving, addiction, and addictive disorders (Bowen et al. 2015). Alan Marlatt and colleagues developed an 8-week mindfulness-based relapse prevention (MBRP) program, which integrates mindfulness meditation practices from MBSR with CBT techniques for drug relapse prevention, including practices focused on mindfully attending to cravings (e.g., urge surfing) (Bowen et al. 2009).

Several well-controlled studies suggest that mindfulness interventions impact craving, drug use, and drug relapse rates in at-risk individuals. Mindfully attending to drug cues reduces neural and self-reported craving among smokers (Westbrook et al. 2013), and some initial evidence indicates that mindfulness interventions reduce cravings more than CBT treatment (Garland et al. 2016). Moreover, mindfulness interventions can disrupt the increases in suffering and substance abuse caused by cravings (Witkiewitz & Bowen 2010). Initial RCTs show that mindfulness interventions, compared to TAU or other relapse-prevention programs, reduce substance abuse in at-risk

populations. For example, MBRP has been shown to reduce drug use days and reduce the number of legal problems compared to a standard relapse prevention program at a 15-week follow-up among substance-abusing female criminal offenders (Witkiewitz et al. 2014). A 4-week mindfulness training program, compared to a standard 4-week smoking cessation treatment, reduced cigarette use among heavy smokers posttreatment and at 3-month follow-up (Brewer et al. 2011). Finally, in one of the largest trials to date ($N = 286$), Bowen and colleagues (2014) randomly assigned substance-abusing individuals at a treatment facility to either MBRP, a cognitive-behavioral relapse prevention program, or standard treatment (a 12-step program) and monitored their reported substance abuse during a 12-month follow-up period. Compared to the standard 12-step treatment group, both the MBRP and cognitive-behavioral relapse prevention groups demonstrated a 54% reduction in drug relapse and a 59% reduction in relapse to heavy drinking. Interestingly, the cognitive-behavioral relapse prevention program had early advantages in delaying the time to the first drug relapse relative to the MBRP program, but the MBRP program appeared to have long-term advantages at the 12-month follow-up time point in reducing the number of drug use days (Bowen et al. 2014).

Interim summary of mental health effects. Strong RCT evidence indicates that mindfulness interventions reduce depression relapse rates in at-risk individuals and improve the treatment of drug addiction. Specifically, multiple large RCTs indicate that MBCT reliably reduces the risk of depression relapse during follow-up periods among at-risk individuals and that MBRP (relative to standard relapse prevention programs) improves substance abuse outcomes. There are also several well-controlled studies showing that mindfulness interventions can reduce anxiety, depression, and PTSD symptomatology. In the mindfulness interventions literature, the research on mental health outcomes has made the most progress in comparing mindfulness interventions to other gold-standard clinical treatments, and there are some initial suggestions of contexts in which mindfulness interventions offer similar or additional long-term benefits compared to gold-standard treatments (e.g., antidepressant medication, relapse prevention programs, CBT).

Cognitive and Affective Outcomes

Formal mindfulness training practices focus on training multiple features of attention, such as noticing when the mind wanders, repeatedly reorienting attention back to a focus area (e.g., sensations of breathing), developing sustained attention, and learning how to foster an open accepting form of attention so as not to get caught up in thoughts, emotions, or body sensations. One would expect these attention skills to improve attention-related cognitive outcomes, and RCT studies in predominantly healthy young adult samples show that mindfulness interventions improve behavioral measures of sustained attention (Jensen et al. 2012, Jha et al. 2015, Mrazek et al. 2012, Semple 2010, Zeidan et al. 2010a), working memory performance (Jensen et al. 2012, Mrazek et al. 2013, Zeidan et al. 2010a), and problem-solving performance (Mrazek et al. 2013, Ostafin & Kassman 2012). It could be argued that mindfulness interventions might benefit all types of attention-related outcomes (e.g., sustained attention, task switching, working memory). However, in one of the most well-controlled trials to date, Jensen and colleagues (2012) showed that MBSR demonstrated superior benefits on sustained attention and working memory at posttreatment compared to a relaxation group or an incentivized (motivated) control group but no relative advantage on some measures of set shifting or attentional vigilance and effort.

Mindfulness interventions not only train attention but also develop the skill of maintaining an open and accepting attitude toward experience, which may be important for emotion regulation and affective outcomes (Slutsky et al. 2016). As described in the section Mental Health, there

is mounting evidence that mindfulness interventions reduce negative affect–related outcomes, such as depression and anxiety symptoms or risk of depression relapse in at-risk individuals. There is also some evidence that mindfulness interventions may reduce self-reported measures of negative affect and improve measures of positive affect in healthy populations. For example, Jain and colleagues (2007) showed that a 4-week MBSR program reduced rumination and increased positive states of mind compared to a 4-week somatic relaxation program during a final exam period in students. However, both the mindfulness and relaxation programs had comparable benefits in reducing self-reported psychological distress at postintervention relative to a no-treatment control group. The RCT studies reviewed in this article provide some examples of the effects of mindfulness intervention on cognitive and affective outcomes; more detailed narrative and meta-analytic reviews of this literature have been published elsewhere (e.g., Arch & Landy 2015, Eberth & Sedlmeier 2012, van Vugt 2015).

Interim summary of cognitive and affective outcomes. Among healthy young adult samples, mounting RCT evidence indicates that mindfulness interventions can improve attention-related outcomes (e.g., sustained attention, working memory) and affective outcomes (e.g., reducing rumination).

Interpersonal Outcomes

Research on how mindfulness interventions impact social and relational outcomes is limited, which is surprising given the extensive anecdotal reports that mindfulness training increases feelings of compassion toward others and can enhance one's close relationships. Indeed, some scholars have argued that kindness and compassion toward others might be a critical marker for evaluating whether mindfulness interventions work (e.g., Grossman 2011), and several lines of research suggest that studies on this topic would be fruitful. First, mindfulness interventions have been shown to improve basic processes associated with better interpersonal functioning outcomes, such as buffering stress and increasing perspective taking (for a theoretical and empirical review, see Karremans et al. 2016). Second, initial RCTs using wait-list control designs suggest that 8-week mindfulness interventions impact social functioning outcomes by, for example, reducing loneliness among older adults (Creswell et al. 2012) and improving relationship satisfaction in adult couples (Carson et al. 2004). In the latter case, Carson and colleagues (2004) conducted one of the first daily diary studies to show that 8-week mindfulness training improved daily reports of relationship satisfaction. Moreover, among mindfulness intervention participants, day-level analyses showed that home mindfulness meditation practice on the first day was significantly associated with higher levels of lagged second- and third-day relationship satisfaction, indicating potentially important daily carry-over benefits of home mindfulness meditation practice.

Mindfulness meditation teachers have long emphasized that mindful awareness can foster insights into the nature of one's suffering and that this understanding naturally gives rise to feelings of compassion toward the self and others (Gunaratana 2011), but little scientific work has attempted to link mindfulness interventions with compassion-related outcomes. Two small RCT studies show that mindfulness meditation training increases compassionate prosocial behaviors such that participants who completed either a 2-week Headspace mindfulness smartphone app intervention or an 8-week group-based mindfulness intervention were more likely to give up their chair to a female confederate on crutches, which was operationalized as a lab-based behavioral measure of compassion (Condon et al. 2013, Lim et al. 2015). This work provides an initial indication that mindfulness interventions increase prosocial outcomes; more research is needed to evaluate whether feelings of compassion mediate these behavioral effects.

It is important to note that mindfulness interventions can be distinguished from compassion (or loving-kindness) meditation programs, which have been receiving more scientific interest in recent years (e.g., Fredrickson et al. 2008). Little is known about the comparative effects of mindfulness versus compassion interventions, but in the above study, Condon et al. (2013) showed that the 8-week mindfulness intervention produced equivalent elevated levels of prosocial behavior at postintervention compared to a well-matched 8-week compassion meditation intervention. One intriguing possibility is that these intervention benefits occurred via dissociable pathways. Loving-kindness meditation practices focus on the explicit generation of positive feelings toward the self and others, whereas mindfulness meditation practices aim to foster an open awareness of experience (as opposed to fostering any specific positive affective states). Thus, one hypothesis is that compassion meditation interventions affect outcomes via positive affect mechanisms, whereas mindfulness interventions affect outcomes through metacognitive awareness and decentering mechanisms (see section Mechanisms of Mindfulness Interventions, below) (Feldman et al. 2010).

Decentering: a mechanism of change involving observing internal experiences from a more objective third-person perspective

Interim summary of interpersonal outcomes. There is currently little mindfulness intervention RCT research on interpersonal outcomes, but initial studies suggest that mindfulness interventions may improve relational outcomes (e.g., relationship satisfaction and prosocial behaviors).

EMBEDDING MINDFULNESS INTERVENTIONS IN INSTITUTIONS AND ACROSS THE LIFE SPAN

First-generation mindfulness intervention studies primarily focused on treating adult patients in clinic settings. Over the past 10 years, there has been a shift toward moving mindfulness intervention RCTs out of the clinic and into institutional settings (e.g., the workplace, schools, prisons, the military, and sport settings) and populations spanning the entire life span (e.g., pregnant women, children, and older adults). High-quality RCT studies are needed to evaluate the safety, efficacy, and effectiveness of mindfulness interventions in these particular contexts. Some initial studies suggest that embedding mindfulness interventions into the workplace (either with group-based or Internet-based training programs) may reduce stress and boost job satisfaction among workers (for a review, see Good et al. 2016). Likewise, mindfulness training programs may be effective in buffering the negative effects of stress in soldiers during high-stress periods (Jha et al. 2010, Johnson et al. 2014).

Initial studies of mindfulness interventions across the life span are also promising. Some pilot RCT evidence shows that mindfulness interventions reduce pregnancy anxiety and depressive symptoms during and following pregnancy (Dimidjian et al. 2016, Guardino et al. 2014). A current trend in research is the development of adapted mindfulness interventions for children, and some initial evidence indicates that classroom mindfulness interventions reduce stress, reduce aggressive behavior, and improve cognitive performance (Flook et al. 2015, Schonert-Reichl et al. 2015, Zenner et al. 2013). In one of the largest RCTs to date ($N = 300$), low-income and predominantly African American urban middle school children were randomly assigned to receive either a classroom-adapted MBSR program or a health education program. At posttreatment, MBSR program participants had greater self-reported improvements in mood, coping, and rumination relative to health education program participants (Sibinga et al. 2016). Finally, in relation to late life, wait-list controlled RCTs also suggest that mindfulness interventions have the potential to improve markers of healthy aging among older adults (e.g., executive function, inflammation) (Creswell et al. 2012, Moynihan et al. 2013).

MECHANISMS OF MINDFULNESS INTERVENTIONS

With high-quality mindfulness intervention RCTs demonstrating promising initial effects on outcomes, there has been growing interest in the mechanisms driving these effects. Mindfulness interventions certainly change a number of processes, including both mindfulness-specific (e.g., acceptance and emotion regulation mechanisms) and non-mindfulness-specific (e.g., positive treatment expectancies) processes (e.g., Creswell et al. 2014). But which mechanistic processes are critical for helping explain the effects of mindfulness intervention on outcomes? In the following sections, I consider some of the psychological and neurobiological mechanisms of mindfulness interventions that have been studied (for some recent reviews, see Brown et al. 2015, Creswell & Lindsay 2014, Hölzel et al. 2011b, Tang et al. 2015).

Psychological Mechanisms

Although a great deal of research has focused on self-reported mindfulness (as measured by questionnaires) as a primary psychological mechanism of change, the evidence is mixed. A recent meta-analysis indicates a moderate positive effect size in mindfulness interventions increasing self-reported mindfulness ($g = 0.53$), and initial evidence in at least 10 studies indicates that increases in self-reported mindfulness statistically mediate improvements in self-reported outcomes, such as reductions in perceived stress or anxiety symptoms (see Visted et al. 2014, table 2). In one example, MBSR was shown to increase self-reported mindfulness compared to an active present-centered group therapy program (without a mindfulness component); these improvements in self-reported mindfulness were associated with decreases in PTSD symptomatology among veterans (Polusny et al. 2015). However, these promising effects are offset by the fact that approximately 50% of mindfulness intervention studies fail to show a significant increase in self-reported mindfulness pre-post intervention (i.e., 37 out of 72 trials in a recent meta-analysis failed to show an increase) (Visted et al. 2014). Furthermore, there is currently limited evidence of mindfulness interventions increasing self-reported mindfulness more than active comparison treatments (e.g., relaxation interventions). Some have argued that there are problems inherent with self-reporting mindfulness that undermine the validity of these measures (e.g., self-reporting is subject to socially desirable responding and retrospective reporting biases, it is difficult to know how attentive and aware one is on a daily basis, the meaning of self-reported mindfulness can change with more formal mindfulness training experiences) (Grossman 2011). Given these concerns, investigators have recently begun to develop and test task-based measures of mindfulness (e.g., Levinson et al. 2013) and second-person mindfulness teacher assessments of mindfulness. Advances in the development of mindfulness measures will likely help clarify the mechanistic role of self-report and behavioral measures of mindfulness in the coming years (for a commentary, see Davidson & Kaszniak 2015).

Mindfulness interventions foster an ability to more objectively observe one's moment-to-moment experience, and this decentered mindset (also described as metacognitive awareness or nonattachment) may be an important psychological mechanism of change. Decentering involves observing internal experiences from a more objective third-person stance (Bernstein et al. 2015), which may help one more effectively decide how one wants to respond to thoughts, emotions, or behaviors (Feldman et al. 2010, Golubickis et al. 2016, Papies et al. 2015). Decentering processes hold promise as an explanation for the mindfulness intervention effects seen in some studies. For example, an early study showed that MBCT improved metacognitive awareness in recovered depressed patients (Teasdale et al. 2002); more recently, well-controlled studies showed that self-reported increases in decentering mediated MBSR treatment effects on anxiety reduction in generalized anxiety disorder patients (Hoge et al. 2014) and MBCT-related decreases in depressive symptoms among individuals at risk for depression relapse (Bieling et al. 2012).

Other psychological and behavioral mechanisms of change have been proposed to explain the effects of mindfulness intervention RCTs, although there are currently few methodologically rigorous mindfulness intervention studies testing these mechanisms in statistical mediation analyses or experiments. These include psychological processes such as acceptance and emotion regulation skills (Hölzel et al. 2011b, Lindsay & Creswell 2015), exposure (Baer 2003), reducing ruminative thoughts (Jain et al. 2007), or changing aspects of one's self-concept (e.g., quieting the egoic self) (Carlson 2013, Golubickis et al. 2016). Finally, formal daily home mindfulness meditation practice has been implicitly assumed to be a behavioral mechanism of change for mindfulness intervention effects (considered in more detail in the section Dosing: How Much Mindfulness Intervention Is Needed for Benefits?), although few well-controlled RCT studies have rigorously evaluated this assumption (Carmody & Baer 2009).

Neurobiological Mechanisms

The effects of mindfulness intervention on outcomes are certainly mediated by the brain, and some initial mindfulness intervention RCT studies have employed structural and functional neuroimaging to evaluate neurobiological mechanisms (for a review, see Tang et al. 2015). Formal mindfulness meditation practices (e.g., mindful awareness of breathing) have been shown to activate a distributed network of brain regions, including the insula, putamen, somatosensory cortex, and portions of the anterior cingulate cortex and prefrontal cortex (Hölzel et al. 2007, Tomasino & Fabbro 2016, Zeidan et al. 2015). Some initial evidence also indicates that mindfulness interventions might structurally alter the brain, increasing gray matter density in the hippocampus (Hölzel et al. 2011a), although well-controlled mindfulness intervention studies are lacking. Despite these advances, little is known about the neural mechanisms linking mindfulness interventions with outcomes.

Our theory of mindfulness as a buffer against stress posits that mindfulness training interventions increase the activity and functional connectivity of prefrontal cortical regions that are important in top-down stress regulation while decreasing the activity and functional connectivity in neural regions that are important in gating the fight-or-flight stress response (e.g., amygdala, subgenual anterior cingulate cortex) (Creswell & Lindsay 2014). We have provided some initial supportive evidence for this neural mechanistic account with a RCT of mindfulness versus relaxation training in stressed unemployed adults (Creswell et al. 2016, Taren et al. 2015). Specifically, we showed that a mindfulness meditation retreat (relative to a well-matched relaxation retreat without a mindfulness component) increased resting-state functional connectivity between the default mode network and the stress regulatory region of the dorsolateral prefrontal cortex while also decreasing stress-related resting-state functional connectivity between the amygdala and the subgenual anterior cingulate cortex. Importantly, we found some initial associations linking these brain changes with reduced stress biomarkers (i.e., cortisol, circulating interleukin 6) at a 4-month follow-up time point (Creswell et al. 2016, Taren et al. 2015).

In addition to neural stress health mechanisms, initial mindfulness intervention studies also link brain changes with affective outcomes. Hölzel and colleagues (2013) showed that MBSR intervention–related increases in ventrolateral prefrontal cortex activity (and amygdala–prefrontal connectivity) during an affect-labeling task were associated with reductions in anxiety symptoms in a sample of patients with generalized anxiety disorder. Zeidan and colleagues (2011, 2015) showed that a brief mindfulness intervention (20 min/day for 4 days) decreased both intensity and unpleasantness ratings given to a noxious thermal pain stimulation to the calf and that the neural mechanisms of these mindfulness-related pain-reduction effects were dissociable from the neural mechanisms driving placebo conditioning effects on pain reduction. In combination, these

initial studies suggest that it is possible to identify the putative brain mechanisms that are linked to mindfulness intervention effects, although all of these studies had small sample sizes and focused only on a small subset of the outcomes discussed in the growing mindfulness intervention literature.

DOSING: HOW MUCH MINDFULNESS INTERVENTION IS NEEDED FOR BENEFITS?

One of the most common questions posed by individuals contemplating whether they should enroll in a mindfulness intervention concerns the amount of mindfulness intervention necessary to experience benefits. The current evidence base suggests that even brief mindfulness interventions (e.g., 5–10-min guided mindfulness inductions, 3–4-session mindfulness meditation training) can buffer affective reactivity (e.g., negative affect, craving, pain) and reduce impulsive behaviors immediately following training (Broderick 2005, Papies et al. 2015, Westbrook et al. 2013, Zeidan et al. 2011), although a recent meta-analysis suggests that these brief training effects are small in magnitude ($g = 0.21$) (M. Schumer, E.K. Lindsay, and J.D. Creswell, unpublished manuscript). In contrast, larger doses of mindfulness interventions, such as the 8-week MBSR program, produce moderate-to-large overall effects pre-post training (Baer 2003, Goyal et al. 2014). One illustrative study measured anxiety symptomatology in anxiety disorder patients weekly before, during, and after an MBSR intervention and showed relatively linear declines in anxiety symptoms over the course of the intervention, which were maintained at follow-up (see **Figure 2**)—suggesting a potential dose–response relationship in interventions, with greater doses of mindfulness intervention producing larger scalable effects over the 8-week intervention. However, few published RCTs have tested for mindfulness intervention dose–response relationships (either by experimentally manipulating the intervention dose or by relating measures of class attendance and home mindfulness practice duration with outcomes), which is an area that is in need of more research (see Carmody & Baer 2009).

Different mindfulness intervention teachers recommend a wide range of daily doses of formal mindfulness practice, from 10 min to 1 h or more per day. There is no one-size-fits-all recommendation for how one should dose one's mindfulness intervention training programs. Dosing

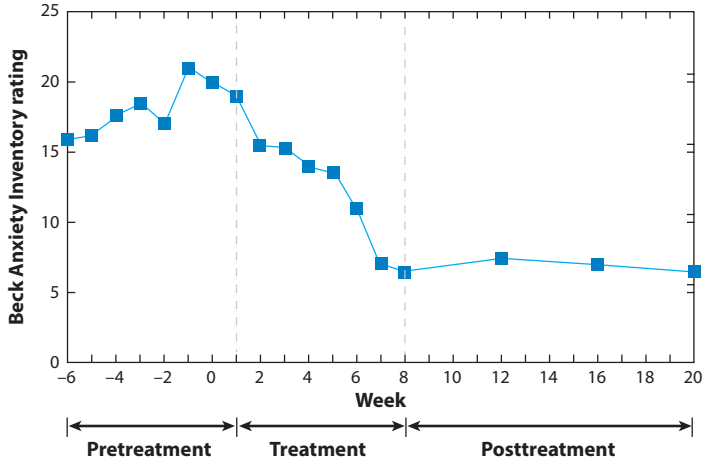

Figure 2

Mean Beck Anxiety Inventory ratings of patients before, during, and after treatment in a mindfulness-based stress reduction program. Figure created using data from Kabat-Zinn et al. (1992).

of mindfulness interventions might follow the same general rules of thumb as dosing aerobic exercise interventions. Larger doses are likely to produce larger effects, the periodicity of the dose is probably important (with regular daily home practice producing larger effects), and there is an upper-bound dose of formal mindfulness intervention that is probably not helpful to participants new to mindfulness practices. Finally, although dosing is important, it is more important for participants to learn how to apply formal mindfulness training skills to stressful or appetitive daily life experiences so that mindfulness skill development can translate into more effective coping.

Dark night experiences: significant adverse events that can occur with intensive mindfulness meditation interventions

RISKS OF PARTICIPATING IN MINDFULNESS INTERVENTIONS

It is not uncommon for participants in mindfulness interventions to report various unpleasant reactions, such as agitation, anxiety, discomfort, or confusion, during formal mindfulness training exercises (although participants also commonly report relaxation and contentment). Indeed, these negative reactions are viewed as an important feature of the psychotherapeutic change process in mindfulness interventions because sustained mindful attention to one's experience is thought to help participants explore and understand the full embodied experience of these reactions, to learn that the experience of these reactions is temporary, and to foster insight into how one reacts to these uncomfortable experiences. These more benign risks aside, there have also been calls to study whether mindfulness interventions can trigger more significant adverse events (Lustyk et al. 2009, Shapiro 1992). For example, a participant who has a life history of trauma might experience the resurfacing of these trauma memories during mindfulness training exercises, potentially triggering a major depressive episode. Researchers have also voiced the concern that individuals who are at risk for psychosis (e.g., schizophrenia) or seizures (e.g., epilepsy) might put themselves at elevated risk for exacerbation of these symptoms if they participate in formal mindfulness exercises (e.g., Walsh & Roche 1979). Currently, there is little empirical published research on the prevalence, type, and severity of these more significant "dark night" experiences with mindfulness interventions. Some observational research suggests that these severe adverse events can occur (albeit infrequently) among individuals going through more intensive residential mindfulness meditation retreats lasting from 2 weeks to 3 months (e.g., Shapiro 1992). The current evidence-based mindfulness interventions (e.g., MBSR, MBCT), which are offered in smaller-spaced doses by trained instructors, carry minimal risks for significant adverse events; furthermore, these mindfulness interventions provide the greatest benefits among high-trauma and high-stress populations (Creswell & Lindsay 2014, Polusny et al. 2015, Williams et al. 2014).

In addition to specific risks and adverse events, it is interesting to consider the possibility that the conscious effort at maintaining awareness on present moment experience might have cognitive costs among individuals who are new to mindfulness interventions. Some studies suggest that training in mindfulness can be initially cognitively depleting. For example, a brief mindful awareness induction was shown to decrease pain tolerance to a cold pressor challenge task, depleting self-regulatory strength (Evans et al. 2014). We also showed that a brief mindfulness meditation training program (25 min/day for 3 consecutive days) buffered psychological perceptions of stress in a laboratory stress challenge task but also increased cortisol reactivity (Creswell et al. 2014). One explanation for this finding is that brief mindfulness training helped foster emotion regulation skills (decreasing psychological stress perceptions) but the extra effort of using a new mindful awareness strategy during a stress task increased cortisol reactivity.

In addition to short-term depleting effects, it is also possible that the cognitive demands of adopting this more reflective awareness of one's present moment experience might disrupt, slow, or bias one's responses on cognitive tasks. Although some initial research indicates that brief mindfulness inductions can reduce evaluative cognitive biases such as the correspondence bias

and sunk cost bias (Hafenbrack et al. 2014, Hopthrow et al. 2016), they can also increase false-memory recall (Wilson et al. 2015). Many open questions about how mindfulness interventions affect cognitive processing variables remain.

DISCUSSION

Our scientific understanding of mindfulness interventions has accelerated over the past two decades, and this review provides some selective highlights of this literature. RCTs provide promising evidence that mindfulness interventions can improve mental and physical health, cognitive and affective factors, and interpersonal outcomes. Some of the strongest and most reliable RCT evidence indicates that mindfulness interventions (and particularly 8-week mindfulness programs, such as MBSR and MBCT) improve the management of chronic pain, reduce depression relapse rates in at-risk individuals, and improve substance abuse outcomes. In these RCT studies, there is consistent evidence that mindfulness interventions improve outcomes relative to TAU or no-treatment control groups, some evidence that mindfulness interventions can improve some outcomes relative to other active behavioral treatments (e.g., relaxation or health education programs), and limited evidence for a relative advantage of mindfulness interventions over other gold-standard pharmacological or behavioral treatments (e.g., CBT).[3] However, few RCT studies have been conducted examining mindfulness intervention effects on interpersonal outcomes (Karremans et al. 2016) or in institutional settings beyond medical or psychological clinics, such as prisons, workplaces, or schools; these areas are ripe for high-quality RCT research.

Although this review has focused on some of the higher-quality RCT mindfulness intervention studies, most of the mindfulness intervention literature to date has methodological limitations (e.g., small samples, lack of active control groups, limited use of high-quality measures, nonblinding of outcome assessors) that currently preclude any definitive statements about the efficacy of mindfulness interventions on many outcomes. Two important areas are especially in need of research attention: measuring formal (and informal) mindfulness practices during and after mindfulness interventions and testing for treatment effects at follow-up time points. Regarding the first point, few mindfulness studies carefully measure and report the amount of daily formal mindfulness practices (and the amount of informal mindful awareness practices) completed during mindfulness interventions, even fewer studies measure whether the amount of daily practice statistically mediates outcomes, and almost no studies have reported how much daily practice participants continue to do in the weeks, months, and years following the completion of formal mindfulness intervention programs (see Barkan et al. 2016). RCT studies that include follow-up time point assessments to measure stability of treatment effects are similarly necessary. This review has highlighted some trials that include follow-up assessments and that provide mixed evidence about the maintenance of effects up to two years following intervention. It is currently unclear what factors are important for determining when beneficial effects are observed at follow-up time points after mindfulness interventions (e.g., in 2-year follow-up periods among participants at risk for depressive relapse) or when postintervention treatment effects disappear at follow-up time points (e.g., pain-reduction benefits disappearing at a 6-month follow-up; see Morone et al. 2016). One implicit assumption (that has gone untested) is that sustained daily mindfulness practices drive the maintenance of intervention effects.

[3]The comparison of CBT to mindfulness interventions is conceptually curious because some mindfulness interventions are hybridized mindfulness-CBT treatments (e.g., MBCT, MBRP), and it is certainly possible that CBT approaches, which aim to bring awareness to automatic thoughts and their effects on behavior, may increase a form of mindful awareness as a central mechanism of change.

I began this review by recognizing the dramatic growth in our scientific understanding of mindfulness and the wide range, from skepticism to fanaticism, of the response among scientists. In this article, I aim to provide a balanced review of the current mindfulness intervention RCT evidence base, along with a consideration of when and where mindfulness interventions demonstrate benefits, an identification of some possible mechanisms for these effects, and a consideration of their potential risks. There are certainly many contexts in which public interest in the benefits of mindfulness interventions has resulted in some fanaticism and characterization of mindfulness training as a panacea treatment. For example, mindfulness interventions are being integrated into schools and the workplace in the absence of a corpus of high-quality well-controlled RCT studies. Many investigators are using mindfulness interventions in patient populations without regard to the active mechanisms of change for affecting specific outcomes of interest (Dimidjian & Segal 2015). Future research on the mechanisms of mindfulness interventions and specification of how (and for whom) mindfulness interventions work will accelerate our basic and clinical efforts in this area.

As the literature on mindfulness interventions has grown, there have also been skeptics who question the value of mindfulness interventions and the ways they are implemented. Some discussions have considered the risks of mindfulness interventions, such as so-called "dark night" experiences that are potentially triggered by mindfulness training (see section Risks of Participating in Mindfulness Interventions, above). Our current understanding of 8-week mindfulness intervention trials indicates a low prevalence of these significant adverse events, with the side effect profile of most individuals consisting of greater insight, well-being, and self-regulated behavior. Skeptics have also questioned the value of secularized forms of mindfulness interventions (such as MBSR and MBCT) that are stripped of the ethical and compassion-related teachings that are common to many Buddhist forms of mindfulness meditation training (Grossman 2011). More research is needed to evaluate these concerns, but initial work suggests that secular forms of mindfulness meditation training may be just as beneficial as spiritual forms (Feuille & Pargament 2015).

As we begin to develop reliable efficacy indications for mindfulness interventions in RCT studies, it will be important to shift our focus to translating this knowledge into effective and sustainable community mindfulness intervention programs; however, there is currently little effectiveness research in this area (Dimidjian & Segal 2015). Epidemiological work suggests that more affluent, healthy white adults are the ones who are most likely to seek out and use mindfulness practices, whereas mindfulness practices are underutilized among low-income minorities with worse health (Olano et al. 2015). From an effectiveness standpoint, this is problematic because our RCT evidence to date suggests that these more high-stress, low-income, and health-compromised individuals would benefit the most from mindfulness interventions (Creswell & Lindsay 2014). Thus, we need to develop effectiveness studies that carefully consider how we can reach out in the coming years to communities of need with evidence-based, cost-effective, and sustainable mindfulness interventions.

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