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How Does Mindfulness Training Affect Health? A Mindfulness-Stress-Buffering Account

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Abstract

Initial well-controlled studies have suggested that mindfulness-training interventions can improve a broad range of mental- and physical-health outcomes (e.g., HIV pathogenesis, depression relapse, inflammation, drug abuse), yet the underlying pathways linking mindfulness and health are poorly understood. In this article, we offer a mindfulness-stress-buffering account to explain these health outcomes, which posits that mindfulness-based health effects are mostly likely to be observed in high-stress populations for which stress is known to affect the onset or exacerbation of disease-pathogenic processes. We then offer an evidence-based biological model of mindfulness, stress buffering, and health.

Keywords

mindfulness, stress, coping, meditation, health psychology

> I began living my life more consciously, for example, in regard to how I coped with stress. I started to take a little time in situations to ask myself: How do I want to deal with this? How am I reacting to my environment?
>
> In stressful situations I could sometimes take a step back and pause before I responded.
>
> —Participants after completing an 8-week mindfulness training program in Majumdar, Grossman, Dietz-Waschkowski, Kersig, and Walach (2002, pg. 726)

Recently, there has been a significant amount of buzz about mindfulness and mindfulness-training programs (e.g., Pickert, 2014). Some of this excitement is due to initial well-controlled studies showing that mindfulness-training interventions can improve a broad range of mental- and physical-health outcomes, such as by reducing risk for relapse in major depression, delaying HIV pathogenesis, improving the treatment of psoriasis, and reducing risk for drug relapse (Bowen, Witkiewitz, Clifasefi, et al., 2014; Creswell, Myers, Cole, & Irwin, 2009; Kabat-Zinn et al., 1998; Teasdale et al., 2000). But much less is known about the mechanisms by which mindfulness gets under the skin to influence these health outcomes (Brown, Ryan, & Creswell, 2007). Some clues might be found in anecdotal reports of mindfulness-meditation practitioners (as in the quotes above), which hint that mindfulness training may impact health by changing one's reactions to stress. Here, we offer a mindfulness-stress-buffering account in four sections: We (a) define mindfulness; (b) formalize a conceptual mindfulness-stress-buffering account; (c) offer an evidence-based biological model of mindfulness, stress buffering, and health; and (d) end with some broader considerations and questions.

What Is Mindfulness?

Mindfulness is a capacity to openly attend, with awareness, to what is happening in one's present-moment experience. Mindfulness is a direct *taking notice* of what is happening right now, regardless of whether one's experience is positive, negative, or neutral. Mindfulness is also about *inviting in* experience with curiosity and

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interest. To say it another way, mindfulness is about monitoring one's present-moment experience with acceptance. Indeed, these two features of mindfulness (monitoring and acceptance) are common to almost all definitions of mindfulness in the literature (Quaglia, Brown, Lindsay, Creswell, & Goodman, 2014).

This capacity to be mindful stands in contrast to much of our daily experience, in which we operate on automatic pilot without much awareness of what we are doing (Bargh & Chartrand, 1999); we easily drift off into mind wandering (Killingsworth & Gilbert, 2010) and, when times get difficult, we often react automatically, finding ways to distract or suppress unwanted experiences (e.g., Kang, Gruber, & Gray, 2013). These mental states can be undesirable (e.g., Killingsworth & Gilbert, 2010), and cultures have developed various practices for fostering greater mindful awareness in daily life (e.g., meditation, centering prayer, journaling, psychotherapy).

Mindfulness has been studied primarily using mindfulness-meditation-training interventions (e.g., Mindfulness-Based Stress Reduction) and self-report measures of state and trait mindfulness (e.g., the Mindful Attention Awareness Scale). An initial review has suggested that mindfulness-training interventions increase self-reported mindfulness (Visted, Vøllestad, Nielsen, & Nielsen, 2014), although the field still faces important questions about the measurement and construct development of mindfulness.

The Mindfulness-Stress-Buffering Account

The stress-buffering hypothesis was first formally described in the social-support literature as a potential explanation for how social support improves health outcomes (Cohen & Wills, 1985). The mindfulness-stress-buffering account posits that mindfulness mitigates stress appraisals and reduces stress-reactivity responses, and that these stress-reduction effects explain how mindfulness affects health outcomes. This account offers two initial predictions. First, it posits that the most pronounced effects of mindfulness on health will be observed in contexts in which participants carry high stress burdens (e.g., unemployed adults, participants high in psychological distress) and, by contrast, that mindfulness-training interventions are unlikely to have much impact on health outcomes in low-stress participant groups. Second, effects of mindfulness on health are predicted in populations for which stress is known to trigger the onset or exacerbation of disease-pathogenic processes or to alter health behaviors (e.g., smoking) that in turn impact disease. Notably, some health conditions and diseases are quite sensitive to stress. For example, stress is thought to be an important trigger for the onset of post-traumatic stress disorder and major depression, and it is known to exacerbate disease-pathogenic processes in HIV infection, inflammatory and cardiovascular diseases, diabetes, obesity, and cancerous-tumor growth and metastasis. For a recent review of the literature linking stress to disease, see Cohen, Janicki-Deverts, and Miller (2007).

Does the current research base support the mindfulness-stress-buffering account? In the most direct test of the account to date, we measured undergraduate participants' trait mindfulness and then manipulated whether they were exposed to a high- versus low-stress situation (Brown, Weinstein, & Creswell, 2012). Specifically, participants were asked to perform speech-based and math tasks in front of evaluators (high-stress condition) or alone into an audio recorder (low-stress condition). Consistent with the stress-buffering hypothesis, results showed that higher levels of trait mindfulness were associated with lower stressor-evoked cortisol reactivity in the high-stress condition, whereas there was no association between mindfulness and cortisol reactivity in the low-stress condition (Brown et al., 2012). Mindfulness-training studies have also shown similar buffering effects on stress appraisals (Creswell, Pacilio, Lindsay, & Brown, 2014) and blood-pressure reactivity to acute stress exposures (Nyklíček, Van Beugen, & Van Boxtel, 2013).

Although studies have provided initial evidence that mindfulness buffers acute stress reactivity, no published studies have yet directly tested the more provocative stress–health predictions from this account—namely, that stress-buffering effects partially or completely account for the positive effects of mindfulness on health outcomes. But a second line of evidence from the mindfulness-training literature offers a promising indication of support. The most provocative demonstrations of the effects of mindfulness-training interventions on health outcomes have been observed almost exclusively in stress-sensitive conditions and diseases, such as in HIV infection, depression, inflammation, and psoriasis (Creswell et al., 2009; Kabat-Zinn et al., 1998; Rosenkranz et al., 2013; Teasdale et al., 2000). Likewise, stress has been shown to accelerate HIV viral replication (Cole, Korin, Fahey, & Zack, 1998), increase the likelihood of major depressive episodes (Gold, Goodwin, & Chrousos, 1988), increase inflammation (Steptoe, Hamer, & Chida, 2007), and impair skin repair (Kiecolt-Glaser, Marucha, Mercado, Malarkey, & Glaser, 1995).

The Mindfulness-Stress-Buffering Account: Biological Pathways

If mindfulness buffers stress, and this stress resilience helps explain how mindfulness affects mental and physical health, then what are the underlying biological stress-reduction pathways? Here, we offer a testable biological model. As depicted in Figure 1, mindfulness is posited to alter stress processing in the brain, which in turn alters peripheral stress-response cascades and subsequent risk for stress-related disease.

Mindfulness has been shown to alter two stress-processing pathways in the brain: It increases the recruitment of prefrontal regulatory regions that may inhibit activity in stress-processing regions (a "top-down" regulatory pathway), and it may also have direct effects on modulating the reactivity of stress-processing regions (a "bottom-up" reduced-stress-reactivity pathway). In support of the top-down regulatory pathway, both trait mindfulness and mindfulness-training interventions have been shown to increase the recruitment of stress-regulatory regions of the prefrontal cortex (e.g., ventral and dorsal regions of the lateral prefrontal cortex), particularly in contexts in which participants are asked to engage in active emotion-regulatory tasks (e.g., affect labeling, reappraisal; Creswell, Way, Eisenberger, & Lieberman, 2007; Modinos, Ormel, & Aleman, 2010). Moreover, mindfulness-training-related increases in prefrontal cortical activation during affect labeling predict improvements in clinical symptoms (i.e., anxiety reduction; Hölzel et al., 2013).

Mindfulness also reduces the reactivity of central stress-processing regions responsible for signaling peripheral stress-response cascades (e.g., the amygdala, anterior cingulate cortex, ventromedial prefrontal cortex, hypothalamus, and parabrachial pons; a bottom-up pathway). Initial neuroimaging studies indicated that mindfulness alters the function and structure of the amygdala, a region important for emotion processing and gating fight-or-flight stress responses (Arnsten, 2009). We found that more mindful individuals have lower resting-state amygdala activity (Way, Creswell, Eisenberger, & Lieberman, 2010) and smaller right-amygdala volumes (Taren, Creswell, & Gianaros, 2013). In addition to having these associations with amygdalar function and structure, mindfulness may reduce functional connectivity of the amygdala with other stress-processing regions. We recently found that mindfulness training reduces stress-related right-amygdala resting-state functional connectivity with the subgenual anterior cingulate cortex, which suggests that mindfulness training may reduce the strength of the connectivity of brain networks driving stress reactivity (Taren et al., 2014).

Our model stipulates that if mindfulness can alter stress-processing dynamics in the brain, these should result in reduced peripheral physiological stress-response cascades in the sympathetic-adrenal-medullary (SAM) and hypothalamic-pituitary-adrenal (HPA) axes. Specifically, mindfulness might alter SAM-axis activation, either (a) via reducing sympathetic-nervous-system activation and its principal stress effectors (secretion of the catecholamines norepinephrine and epinephrine) or (b) via counterregulatory systems known to alter SAM-axis activation, such as increased activity in the parasympathetic nervous system, which can brake sympathetic-nervous-system fight-or-flight stress responses via the vagus nerve (Thayer & Lane, 2000) (Fig. 1). Initial research has suggested that mindfulness training can buffer sympathetic-nervous-system reactivity to acute stressors (blood pressure; Nyklíček et al., 2013), and some research has suggested that mindfulness meditation may increase parasympathetic-nervous-system activation (Ditto, Eclache, & Goldman, 2006), which in turn might foster greater SAM-axis stress regulation over time.

We posit in our biological model that mindfulness might also alter stress-related HPA-axis activation, which would result in the release of glucocorticoids, most notably the stress hormone cortisol. Some evidence suggests not only that trait mindfulness and mindfulness-training interventions may reduce (or potentially normalize) diurnal cortisol secretion (Matousek, Dobkin, & Pruessner, 2010) but, as mentioned earlier, that trait mindfulness may buffer cortisol reactivity to acute stress (Brown et al., 2012).

If mindfulness buffers central (e.g., amygdalar) and peripheral (SAM- and HPA-axis) stress-response cascades, how might these stress-buffering effects impact stress-related health and disease outcomes? Our model specifies that the stress-buffering effects of mindfulness depend on how the biological stress mediators affect disease-specific pathways (Miller, Chen, & Cole, 2009). For many diseases, the stress–disease links are increasingly well characterized, which permits the building of biologic disease-specific models for mindfulness, stress buffering, and health. To illustrate this approach, we recruited a stressed HIV-positive sample to test how mindfulness-meditation training might delay disease-pathogenic processes in a randomized controlled trial (Creswell et al., 2009). This work was shaped by a stress-biology-disease model: We first identified the proximal biological processes driving disease pathogenesis—HIV viral particles replicate and attack specific compartments of the immune system, reducing CD4+ T lymphocyte counts and increasing risk for opportunistic infections and death (Sloan, Collado-Hidalgo, & Cole, 2007). We then considered the role of stress in accelerating HIV replication and CD4+ T lymphocyte declines, noting an established literature showing that stress mediators (e.g., norepinephrine and cortisol) can accelerate this pathogenic process (Capitanio, Mendoza, Lerche, & Mason, 1998; Cole et al., 1998). Consistent with a stress-buffering account, an 8-week mindfulness-meditation training program buffered CD4+ T lymphocyte declines in our sample, providing one of the first controlled demonstrations that mindfulness training can directly impact a biologic (and clinically relevant) disease process (Creswell et al., 2009).

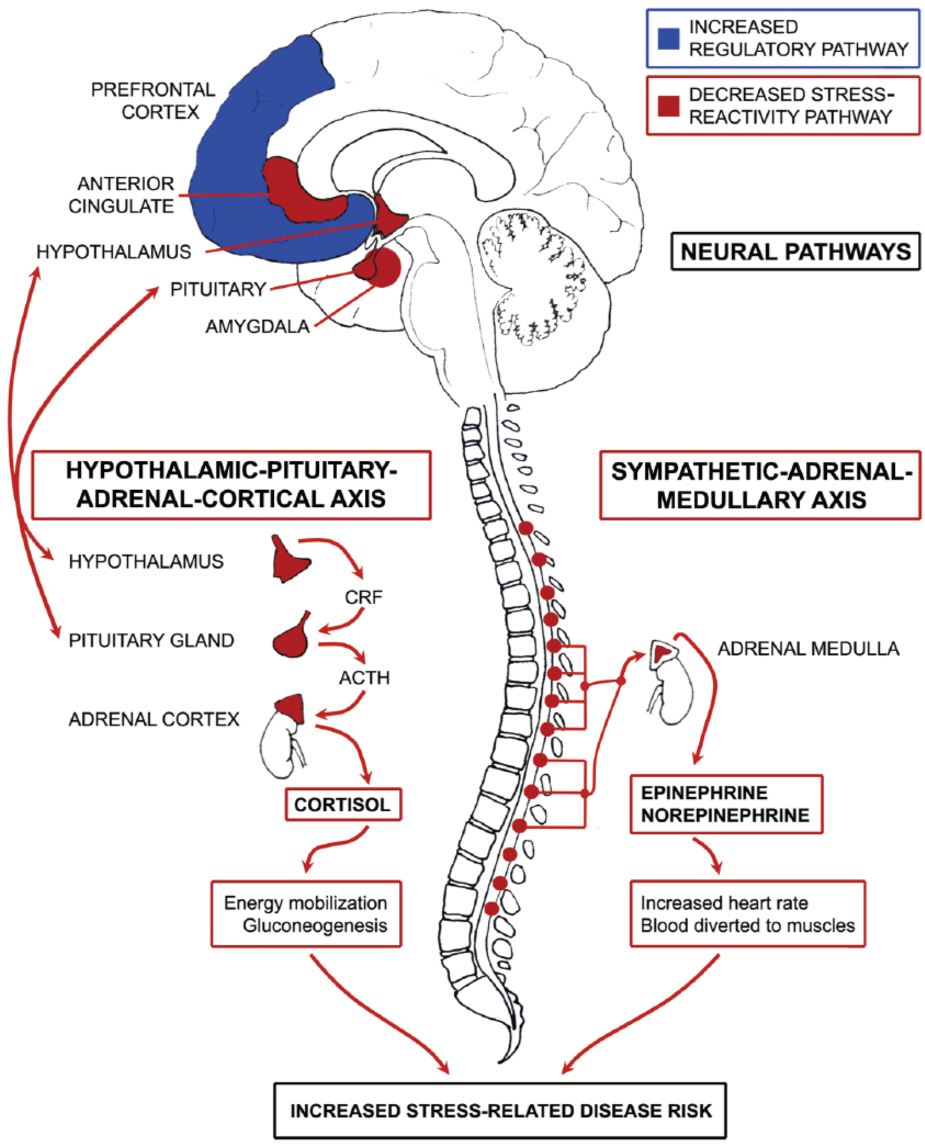

Fig. 1. A conceptual model of the biological pathways linking mindfulness, stress buffering, and stress-related disease outcomes. Blue regions depict regulatory pathways that are activated in mindful individuals or after mindfulness training, whereas red regions depict stress-reactivity pathways that are reduced in mindful individuals or after mindfulness-training interventions. Mindfulness increases the regulatory activity of areas in prefrontal cortex (highlighted in blue) while decreasing reactivity in areas such as the perigenual and subgenual anterior cingulate cortex, the amygdala, and corresponding brain regions implicated in hypothalamic-pituitary-adrenal (HPA) axis (hypothalamus, pituitary gland) and sympathetic-adrenal-medullary (SAM) axis (sympathetic nerve fibers in brainstem and spinal cord) responses (highlighted in red). Note that this diagram does not include parasympathetic-nervous-system projections or interactions, which may play an important regulatory role for SAM-axis responding. Mindfulness is posited to decrease stress-related HPA-axis activation and thus inhibit cortisol production and release from the adrenal cortex. Mindfulness may also decrease activation of the SAM axis, reducing the release of norepinephrine from sympathetic nerve endings and epinephrine release from the adrenal medulla. Cortisol and epinephrine/norepinephrine are important chemical messengers for mobilizing energy and engaging bodily organ systems for fight-or-flight responses, but when these biological stress responses become recurrent, excessive, or dysregulated, they can increase stress-related disease risk. Adapted from "Biological Pathways Linking Mindfulness With Health," by J. D. Creswell, 2014, .

The stress-buffering account and consideration of underlying biological stress-buffering pathways can inform future research aimed at evaluating how mindfulness affects biological health and disease outcomes. The stress-buffering account suggests that mindfulness might alter neural stress-processing dynamics in high-stress participants, reduce SAM- or HPA-axis reactivity (or normalize dysregulated stress signaling in these systems), and subsequently impact stress-related disease-specific biological processes. In future mindfulness-intervention studies, it will be important to test these pathways leading to specific stress-related disease outcomes. For example, recent studies have shown that dysregulated glucocorticoid signaling increases inflammatory-disease risk (Cohen et al., 2012), and catecholamines have been implicated in fostering tumor growth and metastasis in ovarian carcinoma (Thaker et al., 2006). Preliminary research has provided tentative evidence that mindfulness training may impact physical-health outcomes in cancer patients (Ledesma & Kumano, 2009), but our account provides additional hypotheses for mapping the underlying mechanisms influencing these health outcomes.

Conclusions

The nature of how mindfulness impacts health deserves careful consideration to allow for the more effective delivery of mindfulness interventions to at-risk populations. Although we recognize that the science of mindfulness and health is in its infancy (and suffers from methodological limitations and the so-called file-drawer problem), we offer this new stress-buffering account to help specify the conditions under which mindfulness influences health and identify at-risk populations likely to gain health benefits from mindfulness-training interventions. We acknowledge that no mindfulness-training randomized controlled trials (to our knowledge) have directly compared low- and high-stress groups on stress-related health and disease outcomes, which will provide a critical test of this stress-buffering account.

Our stress-buffering account specifically addresses the effects of mindfulness on health, but it is important to note that mindfulness has been shown to impact non-health-related outcomes (e.g., problem solving), and these effects remain to be explained. At this time it is also reasonable to ask whether this stress-buffering account best captures how mindfulness affects health. In our view, initial studies have offered support, but it is also possible that mindfulness training has direct effects on disease processes that are independent of stress-reduction pathways (a direct-effects account). As one example, mindfulness training may have direct effects on positive psychological states (e.g., purpose in life), which in turn impact health via anabolic processes (Low, Bower, Moskowitz, & Epel, 2011; e.g., as one example of a direct-effects pathway, aerobic exercise boosts positive mood and triggers the release of central and peripheral growth factors, such as brain-derived neurotrophic factor; Cotman & Berchtold, 2002).

This article is testament to some initial progress in understanding the biology of mindfulness, stress, and health, but important questions remain about the psychological mechanisms underlying mindfulness and stress resilience. After all, why does this accepting, present-oriented mode of awareness buffer stress responses in the first place? We speculate that mindfulness facilitates a capacity to receptively observe stressors as they arise with acceptance and equanimity, which in turn buffers initial threat appraisals and increases secondary appraisals of coping resources. Indeed, initial electroencephalographic (EEG) evidence suggests that mindfulness may buffer early attentional reactivity to threatening stimuli (Brown, Goodman, & Inzlicht, 2013) and mitigates threat appraisals (Brown et al., 2012; Weinstein, Brown, & Ryan, 2009). Certainly, if mindfulness can buffer primary threat appraisals and facilitate secondary appraisals for coping, it may decrease people's likelihood of subsequent rumination (Jain et al., 2007) and increase their likelihood of using behavioral approach-oriented coping strategies (Weinstein et al., 2009).

Perhaps some clues about the psychological mechanisms underlying mindfulness and stress buffering can be found in participant experiences after mindfulness-meditation-training interventions, such as those expressed in the participant quotes at the beginning of this article. Mindfulness-trained participants commonly report an ability to "take a step back" in stressful situations. Reports like these suggest that mindfulness facilitates a capacity to view oneself and one's current situation from a broader, "decentered' perspective. One intriguing possibility is that this shift in one's stress appraisals sets in motion a powerful cascade for buffering psychological and biological stress reactivity and improving stress-related health outcomes over time.

Recommended Reading

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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